DRAFT

Treatability Study in Support of Remediation by Natural Attenuation for Groundwater at Zone 1

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San Antonio, Texas

and

Westover Air Reserve Base
Chicopee, Massachusetts

May 1997

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DRAFT

TREATABILITY STUDY IN SUPPORT OF REMEDIATION BY NATURAL ATTENUATION FOR GROUNDWATER AT ZONE 1

at

WESTOVER AIR RESERVE BASE
CHICOPEE, MASSACHUSETTS

MAY 1997

Prepared for:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
BROOKS AIR FORCE BASE
SAN ANTONIO, TEXAS

and

439TH SPTG/CEV
WESTOVER AIR RESERVE BASE
CHICOPEE, MASSACHUSETTS

Prepared by:

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EXECUTIVE SUMMARY

This report presents the results of a treatability study (TS) performed by Parsons Engineering Science, Inc. (Parsons ES) at Zone 1, Westover Air Reserve Base, Massachusetts, to evaluate remediation by natural attenuation (RNA) of dissolved fuel-hydrocarbons in the shallow groundwater. Zone 1 encompasses Installation Restoration Program (IRP) sites SS-16, SS-19, and WP-15. The TS focused on the fate and transport of dissolved benzene, toluene, ethylbenzene, and xylenes (BTEX) in the shallow groundwater at Zone 1. Residual and mobile light nonaqueous-phase liquid (LNAPL) present within the vadose zone, phreatic soils, and groundwater serves as a continuing source for the dissolved groundwater contamination. A small quantity of mobile LNAPL is present on the groundwater at site SS-16. Dissolved chlorinated aliphatic hydrocarbons (CAHs) also are present in the shallow groundwater at the WP-15 site; therefore, the potential for RNA of these compounds was investigated as well. The site history and the results of the soil and groundwater investigations conducted previously also are summarized in this report.

Comparison of BTEX, electron acceptor, and biodegradation byproduct isopleth maps for Zone 1 provides strong qualitative evidence of biodegradation of dissolved BTEX compounds. These geochemical data strongly suggest that biodegradation of dissolved fuel hydrocarbons is occurring at the site via aerobic respiration and the anaerobic processes of denitrification, iron reduction, sulfate reduction, and methanogenesis. Patterns observed in the distribution of hydrocarbons, electron acceptors, and biodegradation byproducts further indicate that biodegradation is reducing dissolved BTEX concentrations in site

groundwater. Redox conditions and ratios of dissolved CAHs suggest that chlorinated solvents are being degraded via reductive dehalogenation.

An important component of this study was an assessment of the potential for contamination in groundwater to migrate from the source areas to potential receptor exposure points. The Bioplume II numerical model was used to evaluate the fate and transport of dissolved BTEX in the shallow groundwater under the influence of advection, dispersion, sorption, and biodegradation. Input parameters for the Bioplume II model were obtained from site data collected by Parsons ES. Model parameters that were not measured at the site were estimated using reasonable literature values.

The results of this demonstration suggest that RNA of dissolved BTEX and CAH contamination is occurring at Zone 1; furthermore, the estimated rates of biodegradation, when coupled with sorption, dispersion, and dilution, should be sufficient to reduce and maintain dissolved BTEX concentrations to levels below current regulatory guidelines long before potential downgradient receptors could be adversely affected. The Air Force therefore recommends implementation of RNA and long-term monitoring (LTM) with institutional controls. Conservative modeling suggests that under current conditions, the dissolved BTEX will not migrate 500 feet beyond the current plume extent, and dissolved BTEX contamination throughout the plume will be reduced to concentrations below regulatory levels within 22 years. Future site activities will not change, and the risk to any Base personnel would be minimal, provided institutional controls for soil and groundwater are maintained. Institutional controls such as restrictions on shallow groundwater use at the site would prevent completion of receptor exposure pathways until RNA is complete.

To verify the Bioplume II model predictions, and to ensure that the selected technologies are meeting objectives, the Air Force recommends using 21 LTM wells and 6 point-of-compliance wells to monitor the long-term migration and degradation of the dissolved BTEX plume. In addition to analyses used to verify the effectiveness of RNA,

the groundwater samples should be analyzed for BTEX compounds by US Environmental Protection Agency (USEPA) Method SW8020 and for dissolved chlorinated solvents by USEPA Method SW8260. If data collected under the LTM program indicate that the selected remedial system is not sufficient to reduce BTEX concentrations at downgradient well locations to levels considered protective of human health and the environment, additional corrective actions may be required to remediate groundwater at the site.

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°F	degrees Fahrenheit
$\Delta G°_r$	energy of the reaction
µg/kg	micrograms per kilogram
°C	degrees Celsius
2-D	two-dimensional
AFCEE	Air Force Center for Environmental Excellence
ARB	Air Reserve Base
ASCII	American Standard Code for Information Interchange
atm-m^3/mol	atmosphere-cubic meters per mole
BEIA	Biomedical and Environmental Information Analysis
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
$CaCO_3$	calcium carbonate
CAH	chlorinated aliphatic hydrocarbon
CEA	Corporate Environmental Advisors, Inc.
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cis-1,2-DCE	*cis*-1,2-dichloroethene
Cl^-	chloride
CO_2	carbon dioxide
COCs	chemicals of concern
DO	dissolved oxygen
EAL	Evergreen Analytical Laboratory
ECS	Environmental Compliance Services, Inc.
ES	Engineering-Science Inc.
Fe	total iron
Fe^{2+}	ferrous iron
Fe^{3+}	ferric iron hydroxide
feet	ft/day per day
ft/ft	foot per foot
ft/sec	foot per second
ft^2/day	square feet per day
g/cc	grams per cubic centimeter
gpm	gallons per minute
HDPE	high-density, polyethylene
I-90	Interstate 90
ID	inside-diameter
IRP	Installation Restoration Program
JP-	jet propulsion fuel, grade 4,
K_{oc}	coefficients
LNAPL	light nonaqueous-phase liquid
LTM	long-term monitoring
MADEP	Massachusetts Department of Environmental Protection
MCP	Massachusetts Contingency Plan
MCP	Massechusetts Contingency Plan
mg/kg	milligrams per kilogram
mg/L	milligrams per liter

mm Hg	millimeters of mercury
Mn^{2+}	manganese
MOC	Method of Characteristics
msl	mean sea level
mV	millivolts
N	nitrogen
NCP	National Contingency Plan
NH_3	ammonia
OB&G	O'Brien and Gere Engineers, Inc.
ORD	Offices of Research and Development
ORP	oxidation/reduction potential
OSWER	Solid Waste and Emergency Response
Parsons ES	Parsons Engineering Science, Inc.
PCE	tetrachloroethene
PID	photoionization detector
POC	point-of-compliance
PVC	polyvinyl chloride
QC	quality control
redox	reduction/oxidation
RI/FS	remedial investigation/feasibility study
RMS	root mean square
RNA	remediation by natural attenuation
S^{2-}	sulfide
SAC	Strategic Air Command
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SVOCs	semivolatile organic compounds
TCE	trichloroethene
TMBs	trimethylbenzenes
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TS	treatability study
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	underground storage tank
VOCs	volatile organic compounds

SECTION 1

INTRODUCTION

This report was prepared by Parsons Engineering Science, Inc. [(Parsons ES), formerly Engineering-Science Inc. (ES)] and presents the results of a treatability study (TS) conducted to evaluate remediation by natural attenuation (RNA) of fuel-hydrocarbon- and chlorinated-solvent-contaminated groundwater in Zone 1 at Westover Air Reserve Base (ARB), Chicopee, Massachusetts. Zone 1 encompasses sites SS-16, SS-19, and WP-15. The main emphasis of the work described herein was to evaluate the effectiveness of RNA with long-term monitoring (LTM) for restoration of groundwater contaminated with benzene, toluene, ethylbenzene, and xylenes (BTEX). Additional fuel hydrocarbon and chlorinated solvent compounds were identified as chemicals of concern (COCs) for Zone 1; therefore, the potential for natural attenuation mechanisms to effectively reduce low, dissolved concentrations of these compounds in site groundwater also was qualitatively considered.

As used in this report, RNA refers to a management strategy that relies on natural attenuation mechanisms to remediate contaminants dissolved in groundwater and to control receptor exposure risks associated with contaminants in the subsurface. The United States Environmental Protection Agency (USEPA) Offices of Research and Development (ORD) and Solid Waste and Emergency Response (OSWER) define natural attenuation as (Wilson, 1996):

> *The biodegradation, dispersion, sorption, volatilization, and/or chemical and biochemical stabilization of contaminants to effectively reduce*

contaminant toxicity, mobility, or volume to levels that are protective of human health and the ecosystem.

As suggested by this definition, mechanisms for natural attenuation of organic compounds include advection, dispersion, dilution from recharge, sorption, volatilization, and biodegradation. Of these processes, biodegradation is the only mechanism working to transform contaminants into innocuous byproducts. Natural attenuation occurs through biodegradation when indigenous microorganisms work to bring about a reduction in the total mass of contamination in the subsurface without artificial intervention (e.g., the addition of nutrients). Patterns and rates of natural attenuation can vary markedly from site to site, and within a single contaminant plume at a given site, depending on governing physical and chemical processes. This study is not intended to be a contamination assessment report or a remedial action plan; rather, it is provided for the use of the Base and its prime environmental contractor(s) as information to be used for future decision making regarding this site.

1.1 SCOPE AND OBJECTIVES

Parsons ES was retained by the United States Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division to conduct site characterization and groundwater modeling to evaluate the scientific defensibility of RNA with LTM as a component of remediation for contaminated groundwater at Zone 1.

There were two primary objectives for this project:

- Determine whether natural attenuation processes for fuel hydrocarbons and chlorinated solvents are occurring in groundwater at the site, and if so,
- Evaluate the potential for naturally occurring degradation mechanisms to reduce dissolved fuel hydrocarbon and chlorinated aliphatic hydrocarbon (CAH)

concentrations in groundwater to levels that are protective of human health and the environment.

These objectives were accomplished by:

- Reviewing previously reported hydrogeologic information and soil and groundwater quality data for the site;
- Conducting supplemental site characterization activities to further define the nature and extent of soil and groundwater contamination;
- Collecting geochemical data in support of RNA;
- Developing a conceptual hydrogeologic model of the shallow saturated zone, including the current distribution of contaminants;
- Evaluating site-specific data to determine whether natural processes of contaminant attenuation and destruction are occurring in groundwater for dissolved concentrations of fuel hydrocarbon and chlorinated solvent compounds at the site;
- Using the Bioplume II numerical model to simulate the fate and transport of BTEX compounds in groundwater under the influence of biodegradation, advection, dispersion, and adsorption;
- Evaluating a range of model input parameters to determine the sensitivity of the model to those parameters and to consider several contaminant fate and transport scenarios;
- Determining if natural processes are sufficient to reduce dissolved BTEX and CAH concentrations and limit contaminant plume expansion;

- Using the results of modeling to recommend the most appropriate remedial option based on specific effectiveness, implementability, and cost criteria; and
- Providing a LTM plan that includes LTM and point-of-compliance (POC) well locations, sampling frequency, and recommended analyses.

The field work conducted under this program was oriented toward collecting supplementary hydrogeological and chemical data necessary to document and model natural attenuation mechanisms currently operating at the site. During September 1996, site characterization activities included use of Geoprobe® direct-push technology for soil sample collection and temporary monitoring point installation; aquifer testing; and sampling and analysis of groundwater from temporary groundwater monitoring points and previously installed monitoring wells. Much of the hydrogeological and groundwater chemical data necessary to evaluate RNA was available from previous investigations conducted at this site, at other sites with similar characteristics, or in the technical literature.

Site-specific data were used to develop a fate and transport model for the site, using the groundwater flow and solute transport model Bioplume II, to evaluate processes of natural attenuation. The Bioplume II model was used to simulate the movement of dissolved BTEX in the shallow saturated zone under the influence of biodegradation, advection, dispersion, and sorption. Results of the model were used to assess the effectiveness of natural attenuation mechanisms in reducing dissolved BTEX concentrations and limiting contaminant plume expansion.

Site-specific data also were used to evaluate the potential fate and transport of trichloroethene (TCE), *cis*-1,2-dichloroethene (*cis*-1,2-DCE), and vinyl chloride in the presence of fuel hydrocarbons. Potential biological degradation of these chlorinated solvents via reductive dehalogenation and cometabolic processes was addressed qualitatively.

This report contains nine sections, including this introduction, and five appendices. Section 2 summarizes site characterization activities. Section 3 summarizes the physical characteristics of the study area. Section 4 describes the nature and extent of soil and groundwater contamination, the geochemistry of soil and groundwater, and possible biodegradation mechanisms at the site. Section 5 describes the Bioplume II model and design of the conceptual model for the site, lists model assumptions and input parameters, and describes sensitivity analysis, and model output. Section 6 presents a comparative analysis of remedial alternatives using model results and cost estimates. Section 7 presents an LTM plan for the site. Section 8 presents the conclusions of this work and provides recommendations for further work at Zone 1. Section 9 lists the references used to develop this document. Appendix A contains Geoprobe® borehole logs, monitoring point installation records, and slug test results. Appendix B presents soil and groundwater analytical results. Appendix C contains calculations and model input parameters. Appendix D contains Bioplume II model input and output in American Standard Code for Information Interchange (ASCII) format on a diskette. Appendix E contains cost estimate calculations for the suggested remedial alternatives.

1.2 FACILITY BACKGROUND

Westover ARB is located in Hampden County in south-central Massachusetts. The Base covers approximately 2,400 acres in the northeastern portion of the city of Chicopee, within the Connecticut River Valley. The Base is in close proximity to Interstate 90 (I-90, the Massachusetts Turnpike) and I-91 (a major north-south route), and is 90 miles west of Boston. The land use around the Base is a mix of recreational, rural, residential, and industrial/commercial development.

The Base became operational in April 1940, and served as a training center for the 359th Fighter Group until 1945. After World War II, the Base served the Air Transport Command, which in 1948 became the Military Air Transport Services. From 1956 to

1974, the Base was used by Strategic Air Command (SAC) crews operating B-52s. Westover's 99th Bomb Wing was the primary SAC unit flying missions in the Vietnam War. The Air Force Reserve came to Westover in 1965, and in 1974 the Base was deactivated to become an Air Force Reserve Base. Westover's world-wide mission increased with the arrival of 16 C-5As in 1987. Currently the Base is the nation's largest Air Force Reserve Base and is operated by a work force of 1,200 civilians, including 533 Air Reserve technicians. Over 4,000 reservists from all military branches throughout the northeastern US serve at Westover ARB.

Zone 1 is located in the central portion of the Base, near the southern end of the main aircraft hangars (Figure 1.1). Zone 1 was designated in order to address three identified sites in the vicinity of the flight line as a single entity. The sites are SS-16, SS-19 and WP-15.

SS-16 consists of two large hangars, Buildings 7000 and 7040; a jet fuel pump house complex; and the surrounding aircraft taxiways and parking apron (Figure 1.2). In 1986, during the geotechnical investigation for Building 7040, petroleum odors were observed 18 feet below ground surface (bgs) in the Building 7000 and pump house area. On April 19, 1988, a major fuel spill occurred at SS-16 while a contractor was flushing fuel lines. Approximately 2,200 gallons of jet propulsion fuel, grade 4, (JP-4) was spilled, and about 1,000 gallons of the fuel was recovered. Soil was excavated to a depth of approximately 6 feet bgs, with 800 cubic yards of soil being removed (UNC Geotech, 1991). A fuel pit associated with SS-16 in the grassy area on the eastern side of Zone 1 also is a suspected source for dissolved fuel hydrocarbons in the groundwater.

Site SS-19 is a former fuel pump house and 19 associated underground storage tanks (USTs). The exact dates, locations, and amounts of fuel released at this site are unknown. The tanks were removed before 1991, and the excavations were filled with the contaminated soil.

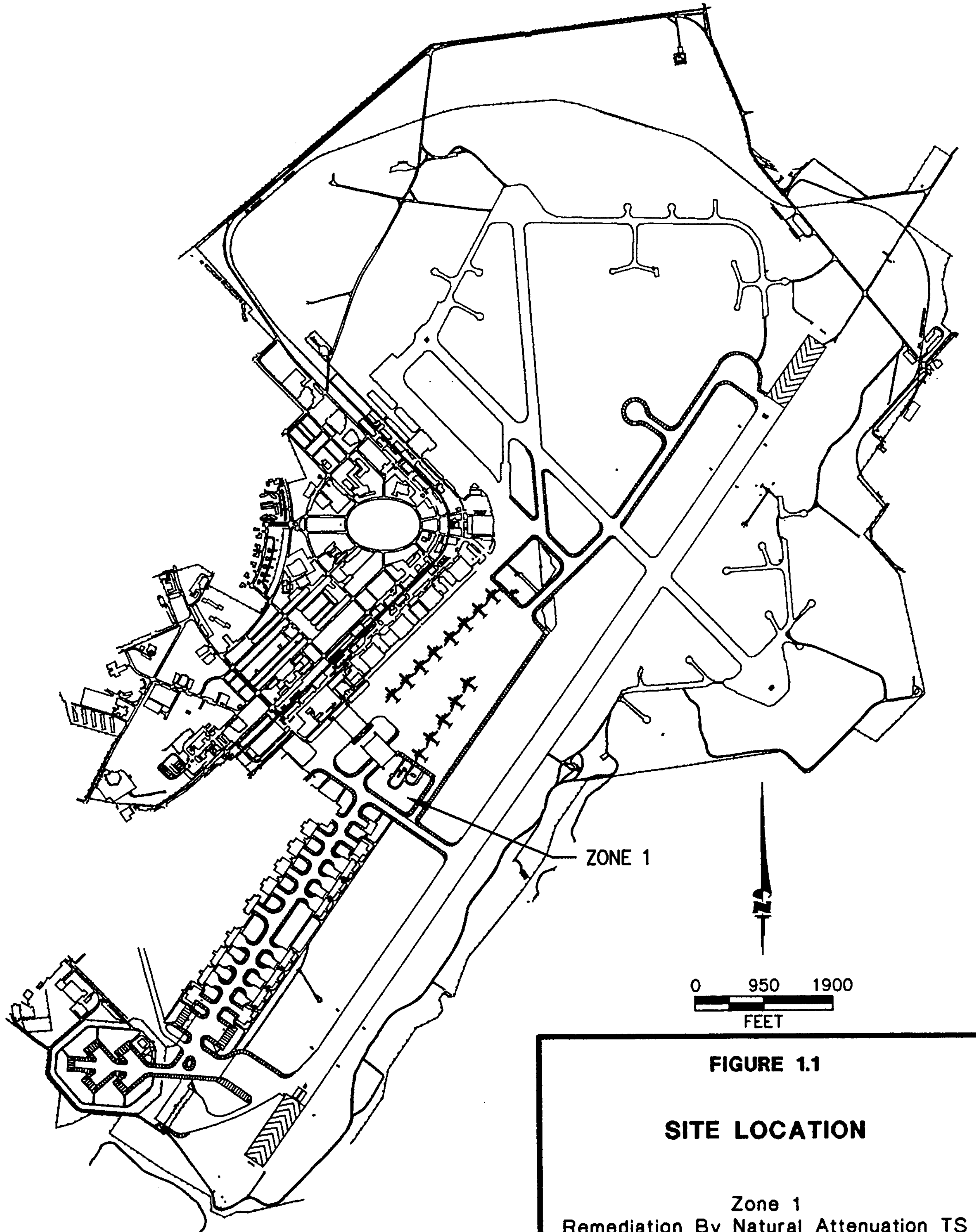

FIGURE 1.1

SITE LOCATION

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

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Denver, Colorado

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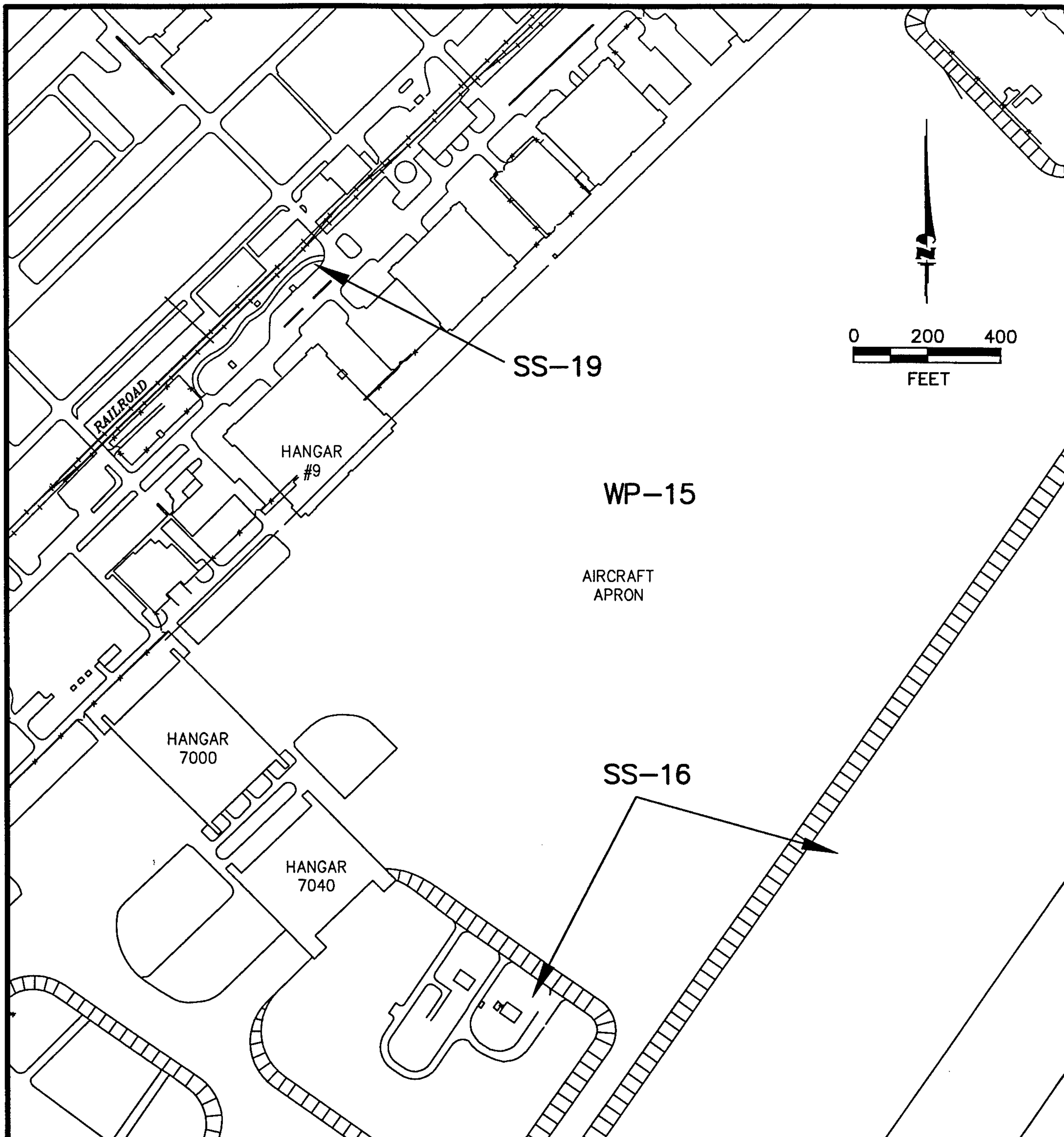

FIGURE 1.2

SITE LAYOUT

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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Site WP-15 is a former industrial wastewater treatment plant that was in operation from 1956 through 1988. Contamination is thought to be the result of small periodic releases from associated USTs that have since been removed.

The three sites in Zone 1 have been addressed both individually and in groups through several environmental investigations. In 1982, an Installation Restoration Program (IRP) records search was conducted by CH_2M Hill (1982). At this time, only site WP-15 was identified. ES (1988) was responsible for site characterization activities in 1986, and the resulting Phase II, Stage 2 confirmation/quantification report, which identified SS-16 as part of the Westover ARB IRP. UNC Geotech (1991) conducted work in 1989 for a remedial investigation/feasibility study (RI/FS) of eight sites, including SS-16 and WP-15. In January 1990 Environmental Compliance Services, Inc. (ECS, 1992) determined that fuel releases from site SS-19 had occurred. A Phase I limited site investigation was conducted at SS-19 in 1991 [Corporate Environmental Advisors, Inc. (CEA), 1991], and the site was included in the Basewide groundwater sampling program conducted by ECS (1992). In 1993, 1994, and 1995 O'Brien and Gere Engineers, Inc. (OB&G, 1994a, 1994b, 1995a, and 1995b) collected field data to produce a supplemental RI/FS for SS-19 and an LTM report for the Zone 1 area (OB&G, 1996).

Previous investigations have detected BTEX contamination in groundwater and soil samples collected within the SS-16 area and at upgradient sites SS-19 and WP-15. The extent of soil contamination has not been fully defined based on the limited soil analytical data. The groundwater BTEX plume from SS-19 has migrated toward SS-16 and is commingling with the dissolved BTEX plume at SS-16. Previous investigations detected the groundwater BTEX concentrations in excess of 15,000 micrograms per liter (µg/L) in the SS-19 portion of Zone 1, while maximum BTEX concentrations at SS-16 were about 5,000 µg/L (OB&G, 1996). At the former industrial wastewater treatment plant (WP-15), dissolved groundwater BTEX concentrations were below 40 µg/L in January 1996.

Historically, mobile light nonaqueous-phase liquid (LNAPL) has been observed in some Zone 1 monitoring wells (OB&G, 1996).

SECTION 2
SITE CHARACTERIZATION ACTIVITIES

This section presents the methods used by Parsons ES personnel to collect site-specific data at Zone 1, Westover ARB, Massachusetts. To meet the requirements of the RNA demonstration, additional data were required to evaluate near-surface geology, aquifer properties, and the extent of soil and groundwater contamination. Site characterization activities involved using the Geoprobe® direct-push system for soil sampling and temporary groundwater monitoring point placement. Groundwater sampling was accomplished during this investigation using both temporary monitoring points and previously installed monitoring wells. Hydraulic conductivity (slug) tests were conducted at several of the site monitoring wells. Previously collected data and data collected under this program were integrated to develop the conceptual hydrogeologic site model and to aid with interpretation of the physical setting (Section 3) and contaminant distribution (Section 4).

The following sections describe the procedures that were followed when collecting site-specific data. Additional details regarding investigative activities are presented in the TS work plan (Parsons ES, 1996).

2.1 SOIL SAMPLING AND MONITORING POINT INSTALLATION

The majority of Geoprobe®-related field work occurred between September 10 and September 17, 1996, and consisted of soil sampling and temporary groundwater monitoring point installation. Sixteen monitoring points were installed at 13 locations during this time to assist in the characterization of contaminant distribution and shallow

groundwater flow system at Zone 1. These points are identified as MP-1 through MP-14 (excluding MP-6), with MP-5, MP-11, and MP-14 having both deep and shallow points. The monitoring point locations are shown on Figure 2.1; Table 2.1 presents completion details.

Nested points were installed in pairs adjacent to each other or existing wells. Points screened across the water table (i.e., shallow points) were designated by the suffix "S"; and points screened deeper in the shallow aquifer (i.e., deep points) were designated by the suffix "D". Monitoring points installed adjacent to an existing groundwater monitoring well (i.e., MP-7, MP-8, MP-9, MP-12, and MP-13) are screened approximately 40 feet bgs in the glacial outwash. Monitoring point MP-10 was screened across the water table. These monitoring point locations were selected to provide the hydrogeologic data necessary for implementation of the Bioplume II model and to evaluate the occurrence and rate of natural attenuation. These activities were performed according to the procedures described in the work plan (Parsons ES, 1996) and reviewed in the following sections.

2.1.1 Geoprobe® Operation and Soil Sampling Procedures

The Geoprobe® system is a hydraulically powered percussion/probing machine used to advance sampling tools through unconsolidated soils. This system provides for the rapid collection of soil, soil gas, and groundwater samples at shallow depths while minimizing the generation of investigation-derived waste materials. For convenience, throughout this report, operation of the Geoprobe® is referred to as "drilling".

2.1.1.1 Pre-Drilling Activities

All subsurface utility lines or other man-made subsurface features were located, and proposed drilling locations were cleared and approved by the Base prior to any drilling activities. Water used in equipment cleaning or grouting was obtained from an onsite potable water supply designated by the Base.

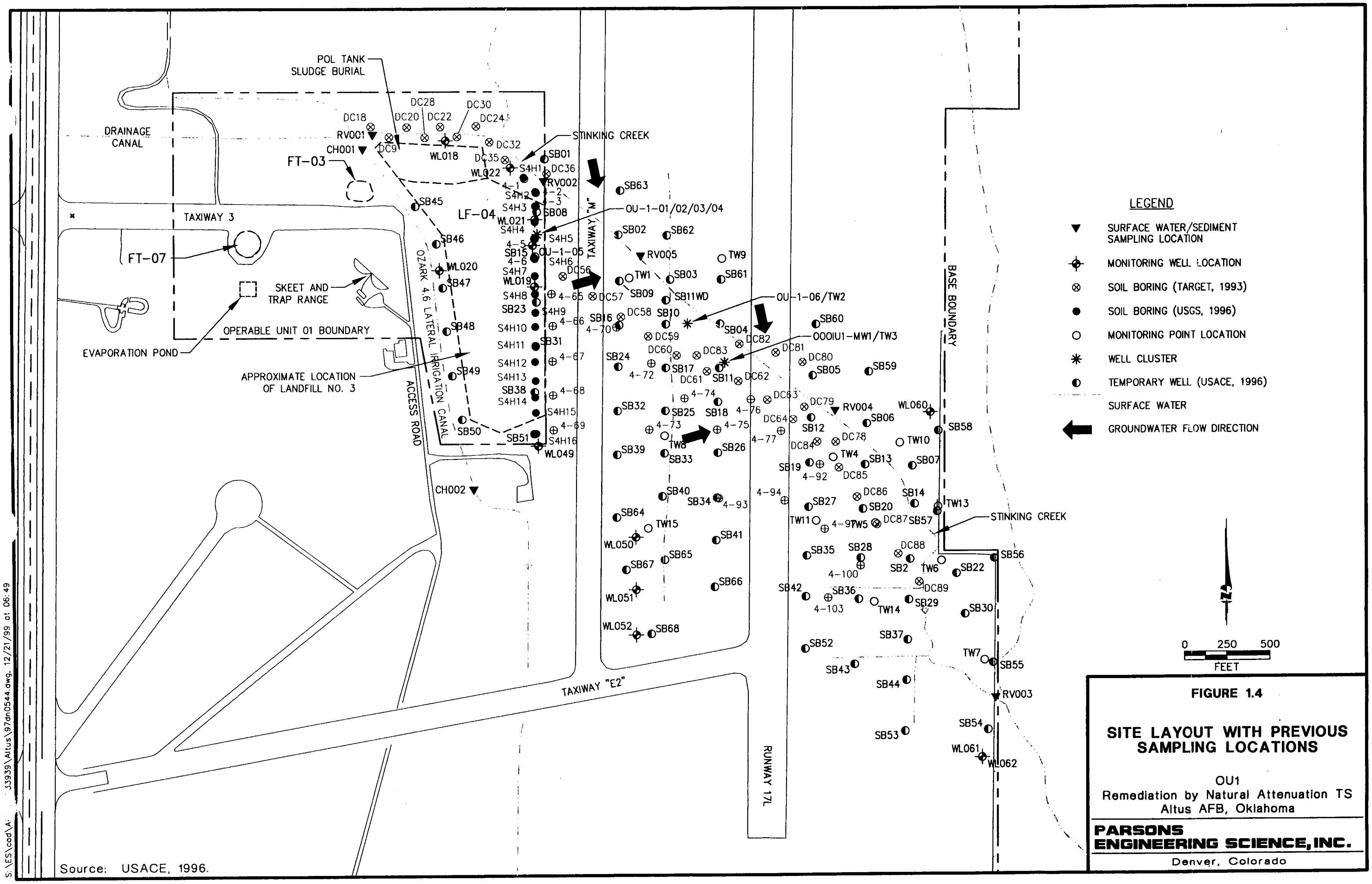

FIGURE 1.4

SITE LAYOUT WITH PREVIOUS SAMPLING LOCATIONS

OU1
Remediation by Natural Attenuation TS
Altus AFB, Oklahoma

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

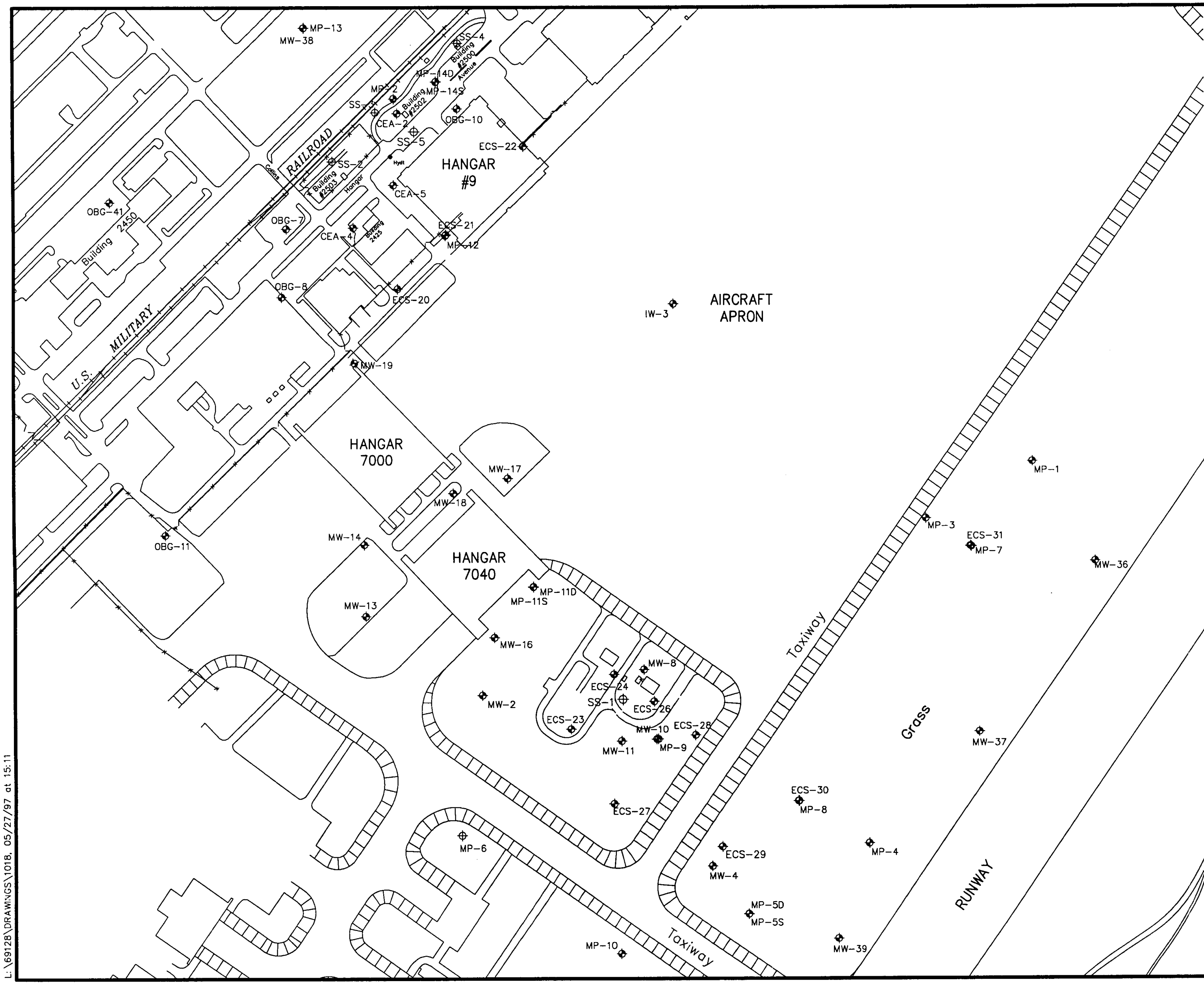

FIGURE 2.1

SAMPLING LOCATIONS

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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TABLE 2.1
MONITORING POINT AND WELL INSTALLATION DATA
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Well/Point ID	Installation Date	Easting	Northing	Total Depth (feet bgs)[a/]	Screened Interval (feet bgs)	Riser Diameter (inches)
CEA-2	3/1/91	316678.85	436979.47	20	10-20	2
CEA-4	3/4/91	316540.52	436626.18	20	10-20	2
CEA-5	3/4/91	316667.55	436759.04	20	10-20	2
ECS-20	12/18/91	316676.37	436451.34	22	10-20	2
ECS-22	12/17/91	317073.33	436877.58	22	10-20	2
ECS-23	12/17/91	317216.61	435072.55	22	20-Oct	2
ECS-24	12/11/91	317351.29	435242.01	22	10-20	2
ECS-26	12/11/91	317477.15	435158.22	22	10-20	2
ECS-27	12/10/91	317350.79	434841.38	22	10-20	2
ECS-28	12/11/91	317606.07	435053.83	22	20-Oct	2
ECS-29	12/12/91	317689.39	434710.78	22	10-20	2
ECS-30	12/12/91	317928.35	434850.17	22	10-20	2
ECS-31	12/12/91	318468.26	435638.01	22	10-20	2
IW-3	1986	317541.58	436392.45	30	11.0-26.0	2
MP-1	9/10/96	318661.56	435899.57	19.5	14-19	0.5
MP-2	9/10/96	316667.72	437024.39	16.5	11.5-16.5	0.5
MP-3	9/11/96	318330.47	435723.82	19.5	14.5-19.5	0.5
MP-4	9/12/96	318149.09	434720.82	20	15-20	0.5
MP-5S	9/12/96	317770.33	434505.78	20	19.5-20	0.375
MP-5D	9/12/96	317770.05	434506.09	38	37.5-38	0.375
MP-7	9/12/96	318470.93	435636.48	40	39.5-40	0.375
MP-8	9/12/96	317930.49	434850.28	31	30.5-31	0.375
MP-9	9/12/96	317489.97	435041.70	38	37.5-38	0.375
MP-10	9/12/96	317370.73	434383.34	24	19-24	0.5
MP-11S	9/14/96	317100.84	435512.78	22	17-22	0.5
MP-11D	9/12/96	317100.96	435514.15	38	37.5-38	0.375
MP-12	9/14/96	316876.08	43666.00	38	37.5-38	0.375
MP-13	9/14/96	316386.63	437244.03	38	37.5-38	0.375
MP-14S	9/14/96	316800.12	437075.38	18	13-18	0.5
MP-14D	9/14/96	316801.27	437076.62	38	37.5-38	0.375
MW-2	NA[b/]	316940.81	435177.69	22.5	15-25	2
MW-8	NA	317445.10	435256.98	30	13-29	2
MW-10	NA	317484.65	435041.35	30	14-29	2
MW-11	NA	317374.66	435035.42	30	14-29	2
MW-13	NA	316576.12	435422.65	25.5	13.3-23.3	2
MW-14	NA	316571.95	435644.00	28	14.3-24.3	2
MW-16	NA	316979.04	435356.62	29.5	15.0-25.0	2
MW-17	NA	317022.13	435849.36	30	11.0-26.0	2
MW-18	NA	316852.38	435802.42	29	11.0-26.0	2
MW-19	NA	316543.55	436209.69	29	10.0-25.0	2
MW-36	6/22/93	318856.36	435589.83	27	10.0-25.0	2
MW-37	6/22/93	318493.54	435063.30	28	13.0-28.	2
MW-38	9/23/92	316385.98	437243.45	15	5.0-15.0	2
MW-39	NA	318051.58	434430.00	NA	NA	NA
OBG-7	6/15/93	316331.73	436622.87	27	10-25	2
OBG-8	6/16/93	316316.94	436411.58	27	10-25	2
OBG-10	6/16/93	316867.42	436993.63	27	10-25	2
OBG-11	1/5/94	315948.30	435673.76	27	10-25	2
OBG-41	NA	315777.08	436705.28	NA	NA	2

a/ bgs = below ground surface.

b/ NA = data not available.

2.1.1.2 Equipment Decontamination

Prior to arriving at the site and between each drilling location, all probe rods, tips, sleeves, pushrods, samplers, tools, and other downhole equipment were decontaminated using an Alconox® detergent and potable water solution followed by a potable water wash. Fittings, tips, and samplers, which came into direct contact with soil samples, underwent an additional rinse with isopropyl alcohol followed by a final rinse with deionized water. Precautions were taken to minimize impacts on the areas surrounding decontamination operations. All decontamination activities were conducted in a manner so that the excess water was controlled and not allowed to flow into any open borehole. All decontamination fluids were collected in 5-gallon buckets and redistributed over site soils.

2.1.1.3 Drilling and Soil Sampling

Drilling was accomplished using the Geoprobe® direct-push technology. Where possible the boreholes were sampled continuously. Where two points were installed adjacent to each other (i.e., nested), only the shallow point was logged and sampled. Logging and sampling of deep boreholes was not performed because saturated samples could not be retained in the soil sampler. A final borehole diameter of 2 inches was used for the installation of shallow points with 0.5-inch inside-diameter (ID) casing. For the 0.375-inch-ID deep monitoring points, a final borehole diameter of 1 inch was utilized.

The Parsons ES field geologist observed Geoprobe® and monitoring point installation activities and maintained a detailed descriptive log of recovered subsurface materials. Final geologic borehole logs are presented in Appendix A. These logs contain:

- Sampled interval (top and bottom depth);

- Presence or absence of contamination based on odor, staining, and/or photoionization detector (PID) readings;
- Soil description, including color, major textural constituents, minor constituents, relative moisture content, plasticity of fines, cohesiveness, grain size, structure or stratification, and any other significant observations; and
- Lithologic contacts, with the depth to contacts and/or significant textural changes recorded to the nearest 0.1 foot.

The Geoprobe®-collected soil samples were obtained using 4-foot by 1.5-inch-ID and 2-foot by 1-1/16-inch-ID sampling devices. The large sampler was used for the uppermost 10 feet of soil. The smaller sampler was then used for the remainder of the borehole in an attempt to minimize the smearing of surface contamination into deeper portions of the borehole. A probe-drive sampler attached to the leading end of the probe rods serves both as the driving point and for sample collection. To collect a soil sample, the sampler was pushed or driven to the desired sampling depth, the drive point was retracted to open the sampling barrel, and the sampler was subsequently pushed into the undisturbed soils. The soil cores were retained within a clear acetate liner inside the sampling barrel. The probe rods were then retracted, bringing the sampling device to the surface. The soil sample was then extruded from the liners for visual lithologic logging and PID headspace screening.

Bags containing soil samples collected for the headspace screening procedure were quickly sealed and stored for 15 minutes or longer at the ambient temperature. Semiquantitative measurements were made by puncturing the bag seal with the PID probe and reading the concentration of the headspace gases. The PID relates the concentration of total volatile organic compounds (VOCs) in the sample to an isobutylene calibration standard. The PID also was used to monitor for VOCs in the worker breathing zone.

Soil samples collected in the large-bore soil sampler were removed from the sampler (22 inches long by 1.06-inch outside diameter) as a composite of soil in 1-foot intervals within a sample liner, transferred to jars, and submitted to a laboratory for analysis of BTEX, and total organic carbon (TOC) by the methods listed in Table 2.2. For each soil sample the Parsons ES field scientist recorded the following information:

- Requested analytes;
- Sample interval (top and bottom depth);
- Sample identification;
- Sampling date; and,
- Sample collector's initials.

Fifteen soil samples were collected for laboratory analysis from areas in the vicinity of the SS-16, SS-19 and WP-15 in Zone 1. These soil samples were collected immediately above and/or immediately below the water table, and where PID readings were elevated or visible contamination was present.

2.1.2 Monitoring Point Installation

Groundwater monitoring points were installed in 16 boreholes at 13 locations under this program (Figure 2.1). Detailed monitoring point installation procedures are described in the following paragraphs.

2.1.2.1 Materials Decontamination

Monitoring point completion materials were inspected by the field geologist and determined to be clean and acceptable prior to use. All monitoring point completion materials were factory sealed in plastic wrap. Pre-packaged casing, sand, and bentonite

TABLE 2.2
ANALYTICAL PROTOCOL FOR GROUNDWATER AND SOIL SAMPLES
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

MATRIX Analyte	METHOD	FIELD SCREEN (F) OR ANALYTICAL LABORATORY (L)
WATER		
Total Iron	Colorimetric, Hach Method 8008	F
Ferrous Iron (Fe+2)	Colorimetric, Hach Method 8146	F
Manganese	Colorimetric, Hach Method 8034	F
Sulfide	Colorimetric, Hach Method 8131	F
Sulfate	Colorimetric, Hach Method 8051	F
Nitrate	Titrimetric, Hach Method 8039	F
Nitrite	Titrimetric, Hach Method 8507	F
Redox Potential	A2580B, direct-reading meter	F
Oxygen	Direct-reading meter	F
pH	E150.1/SW9040, direct-reading meter	F
Conductivity	E120.1/SW9050, direct-reading meter	F
Temperature	E170.1	F
Alkalinity (Carbonate [CO3-2] and Bicarbonate [HCO3-1])	Titrimetric, Hach Method 8221	F
Carbon Dioxide	CHEMetrics Method 4500	F
Nitrate	E300 or SW9056	L
Nitrite	E300 or SW9056	L
Chloride	E300 or SW9056	L
Sulfate	E300 or SW9056	L
Alkalinity	E150.1	L
Methane	RSKSOP 175[a/] or EAL-SOP-GC404	L
Total Organic Carbon	SW9060	L
Aromatic Hydrocarbons (Including Trimethylbenzene and Tetramethylbenzene)	SW8020A	L
Purgeable Halogenated Volatile Organics	SW8010	L
Total Hydrocarbons	SW8015 Modified	L
SOIL		
Total Organic Carbon	SW9060	L
Moisture	ASTM D-2216	L
Aromatic Hydrocarbons	SW8020	L
Total Hydrocarbons	SW8015	L

[a/]RSKSOP = Robert S. Kerr Laboratory standard operating procedure.

022/729691/WESTOVER/11.XLS/Table 2.2

were used in well construction, and were inspected for possible external contamination before use. Materials that could not be cleaned to the satisfaction of the field geologist were not used.

2.1.2.2 Casing and Screen

Upon completion of Geoprobe® sampling to the proper borehole depth, 16 temporary groundwater monitoring points were installed at 13 locations. Monitoring point construction details were noted on a monitoring point installation record and are summarized in Table 2.1. This information became part of the permanent field record for the site. Monitoring point installation records for Zone 1 are presented in Appendix A.

Seven of the eight shallow monitoring points (MP-1, MP-2, MP-3, MP-4, MP-10, MP-11S, and MP-14S), screened across the water table, were constructed of Schedule 40 polyvinyl chloride (PVC) riser pipe and screen having an ID of 0.5 inch. All well casing and screen sections were flush-threaded; glued joints were not used. A sacrificial stainless steel drive point was pressure-fitted into the bottom of the screen using Teflon® tape. Shallow monitoring point screens were 5 feet long and were factory-slotted with 0.010-inch openings.

The deep temporary monitoring points (MP-5D, MP-7, MP-8, MP-9, MP-11D, MP-12, MP-13, and MP-14D) screened below the water table, and shallow monitoring point MP-5S, were constructed using Teflon®-lined, high-density, polyethylene (HDPE) tubing threaded through the center of the drive rods. The tube was attached to a 0.5-foot-long, 0.375-inch-diameter stainless steel, double-woven wire screen with 0.145-millimeter (0.037-inch) slot size. The screen was threaded into a dedicated stainless steel drive point/implant anchor that remained in place after the drive rods were removed. The field geologist recorded the borehole depth, the lengths of all

casing sections, and the depth to the top of all monitoring point completion materials placed in the annulus between the casing and borehole wall.

2.1.2.3 Filter Pack and Annular Sealant

Placement of a filter pack around the monitoring point casing screens was not possible as a result of the collapse of the sand borehole walls. Therefore, the monitoring points were naturally sand-packed with the formation materials. Due to the sandy nature of the formation materials, well development and purging activities were accomplished without difficulty.

A filter pack of fine grained sand was placed in the portion of the hole which remained open following collapse of the sandy borehole walls. An annular sealant consisting of bentonite chips was typically placed in the top 2 feet of the borehole.

2.1.2.4 Protective Cover

For all newly installed monitoring points, protective 8-inch- or 12-inch-diameter flush-mount casings were set into an approximate 2-foot-square concrete pad to a depth of 0.5 to 1.0 foot bgs. The tops of the covers were placed approximately at ground surface. Monitoring point identifications were permanently inscribed on the well casing and protective cover

2.1.3 Monitoring Point Development

Prior to sampling, monitoring points were developed. Typically, development removes sediment from inside the well casing and flushes fines, cuttings, and drilling fluids from the sand pack and the portion of the formation adjacent to the well screen. Use of the Geoprobe® system to place monitoring points eliminates cuttings and drilling fluids. As a result, development of monitoring points is primarily intended to minimize the amount of fine sediment that might accumulate in the casing.

Monitoring point development was accomplished using a peristaltic pump with dedicated silicon and HDPE tubing. For monitoring points constructed of 0.5-inch PVC casing, the pump tubing was regularly lowered to the bottom of the shallow points so that fines were agitated and removed from the point in the development water. Monitoring points constructed from 0.375-inch Teflon® lined tubing were developed by attaching a piece of dedicated silicon tubing to the end of the monitoring point and connecting it directly to the peristaltic pump. Development was continued until 10 casing volumes of water was removed from the point and/or the groundwater pH, temperature, conductivity, and dissolved oxygen concentrations had stabilized.

2.2 GROUNDWATER SAMPLING

This section describes the procedures used for collecting groundwater samples. In order to maintain a high degree of quality control (QC) during this sampling event, the procedures described in the site work plan (Parsons ES, 1996) and summarized in the following sections were followed.

Groundwater sampling occurred on September 10 through 15, 1996, and consisted of collecting groundwater samples from 16 temporary monitoring points and from 33 previously installed monitoring wells. Sampling locations are presented on Figure 2.1. Groundwater sampling forms were used to document the specific details of the sampling event for each location. Groundwater samples were analyzed for the parameters listed in Table 2.2. In addition to data from the groundwater sampling conducted under this program, data are available from groundwater sampling events performed at Zone 1 in 1986, 1987, 1989 (two sampling events), 1990, 1991 (three sampling events), 1993, and 1995.

The 33 existing monitoring wells that were sampled under this program included CEA-2, CEA-4, CEA-5, ECS-20, ECS-22, ECS-23, ECS-24, ECS-26, ECS-27, ECS-28, ECS-29, ECS-30, ECS-31, IW-3, MW-2, MW-8, MW-10, MW-11, MW-13,

MW-14, MW-16, MW-17, MW-18, MW-19, MW-36, MW-37, MW-38, MW-39, OBG-7, OBG-8, OBG-10, OBG-11, and OBG-41. Completion data for the temporary monitoring points and previously installed monitoring wells are provided on Table 2.1.

2.2.1 Preparation for Sampling

All equipment used for sampling was assembled and properly cleaned and calibrated (if required) prior to arriving in the field. Special care was taken to prevent contamination of the groundwater and extracted samples through cross contamination from improperly cleaned equipment; therefore, water level indicators and sampling equipment were thoroughly cleaned before and after field use and between uses at different sampling locations. In addition, a clean pair of new, disposable gloves was worn each time a different well/point was sampled.

All portions of sampling and test equipment that contacted the sample were thoroughly cleaned before use. This equipment included the water level probe and cable, equipment for measuring onsite groundwater chemical parameters, and other equipment that contacted the samples. The following cleaning protocol was used:

- Rinse with potable water;
- Rinse with isopropyl alcohol;
- Rinse with distilled or deionized water; and
- Air dry prior to use.

Any deviations from these procedures were documented in the field scientist's field notebook and on the groundwater sampling form. Decontamination fluids were contained and handled as described in Section 2.1.1.2.

As required, field analytical equipment was calibrated according to the manufacturers' specifications prior to field use. This requirement applied specifically to direct-reading meters used for onsite chemical measurements of pH, temperature, conductivity, and dissolved oxygen (DO).

Upon arrival at the monitoring well/point, the area around the well was cleared of foreign materials, such as brush, rocks, and debris. These procedures prevented sampling equipment from inadvertently contacting debris around the monitoring well. Location preparation also included an inspection of the integrity of the well or monitoring point. At this time, irregularities with the protective cover, cap, lock, external surface seal, internal surface seal, well identification, well datum, and pad were noted.

Prior to removing any water from the well or point, the static water level was measured. In all groundwater wells and PVC monitoring points, an electrical water level probe was used to measure the depth to groundwater below the well datum to the nearest 0.01 foot. An oil/water interface probe was used in monitoring well ECS-26 because of the presence of mobile LNAPL. Water levels could not be obtained from the temporary monitoring points constructed of Teflon®-lined HDPE tubing because the tube diameter is too small to accommodate the water level probe. After measurement of the static water level, the water level probe was lowered to the bottom of the well/monitoring point (except ECS-26) for measurement of total well depth (recorded to the nearest 0.01 foot). Based on these measurements, the volume of water to be purged from the wells/points was estimated. Static groundwater levels at all site wells also was measured on September 16, 1996, at the end of all the field activities.

2.2.2 Well/Point Purging and Sample Collection

Sixteen monitoring points and 33 monitoring wells were purged and sampled using a peristaltic pump with dedicated HDPE and silicon tubing. Purging consisted of

removing at least three times the calculated casing volume prior to sample collection. Once three casing volumes of water was removed from the well/point, purging continued until the pH, DO concentration, conductivity, and temperature stabilized.

Within 24 hours of the purge event, groundwater samples were collected from the monitoring wells/points. The samples were transferred directly from the peristaltic pump discharge tubing into the appropriate sample containers. The water was carefully poured down the inner walls of the sample bottle to minimize aeration of the sample. Sample bottles for BTEX, trimethylbenzenes (TMBs), CAHs, and dissolved gas analyses were filled so that no headspace or air bubbles remained within the container. Table 2.2 lists the analyses performed on collected groundwater samples.

2.2.3 Onsite Chemical Parameter Measurement

Measurement of DO, pH, specific conductance, oxidation/reduction potential (ORP), and temperature was performed at the sampling location at the time of sample collection. All other field parameters (e.g., ferrous iron, sulfate, manganese etc.) were measured on site by Parsons ES personnel at the mobile laboratory immediately following sample collection.

DO measurements were taken using an YSI® Model 55B DO meter in a flow-through cell at the discharge of the peristaltic pump. DO concentrations were recorded after the readings stabilized, and in all cases represent the lowest DO concentration observed.

Because the pH, temperature, and the ORP of the groundwater can change significantly within a short time following sample acquisition, these parameters were measured in the field, in the same flow-through cell used for DO measurements. The measured values were recorded on the groundwater sampling record.

Specific conductance measurements were taken using an EXTECH® Oyster or similar meter in the same flow-through cell in which DO was measured. The conductance was recorded on the groundwater sampling record.

An onsite laboratory staffed by Parsons ES personnel was used to analyze for several indicator parameters in groundwater samples collected from pre-existing monitoring wells and newly installed monitoring points (Table 2.1). A Hach® DR/700 colorimeter was used to measure ferrous iron (Fe^{2+}), total iron (Fe), manganese (Mn^{2+}), and sulfide (S^{2-}). Titrations using Hach® reagents were conducted to measure alkalinity [as milligrams per liter (mg/L) calcium carbonate ($CaCO_3$)] and chloride (Cl^-); and CHEMetric® color tests were used to measure ammonia (NH_3) and carbon dioxide (CO_2). These analyses were completed for each groundwater sample after all sample containers had been filled. The sample to be analyzed was poured into a clean glass container, capped, and transported to the Parsons ES on-Base laboratory for analysis. Special care was taken to avoid aerating the sample in the sample container, which could influence the concentrations of reduced and oxidized species. The field holding time for each sample did not exceed 0.5 hour. Care was taken to minimize sample temperature changes and exposure to sunlight.

2.2.4 Sample Handling

The fixed-base analytical laboratory, Evergreen Analytical Laboratory (EAL) of Wheat Ridge, Colorado, provided pre-preserved sample containers where appropriate. The sample containers were filled as described in Section 2.2.3, and the container lids were tightly closed. The sample label was firmly attached to the container side, and the following information was legibly and indelibly written on the label:

- Facility name;
- Sample identification;

- Sample type (groundwater);
- Sampling date;
- Sampling time;
- Requested analyses;
- Preservatives added; and
- Sample collector's initials.

After the samples were sealed and labeled, they were packaged for transport to EAL in Wheat Ridge, Colorado. The following packaging and labeling procedures were followed:

- Samples were packaged to prevent leakage or vaporization from the containers;
- Samples were cushioned to avoid breakage; and
- Ice was added to the cooler to keep the samples cool.

The packaged samples were delivered by overnight courier (Federal Express®) to the laboratory. Chain-of-custody procedures outlined in the project work plan (Parsons ES, 1996) were followed. Hach® laboratory samples were hand delivered to the on-Base Parsons ES laboratory.

2.3 AQUIFER TESTING

Slug tests were conducted at four monitoring well locations to estimate the hydraulic conductivity of the shallow saturated zone at Zone 1. Slug tests are single-well tests used to determine the hydraulic conductivity of an aquifer in the immediate vicinity of the tested well. Slug tests can be used for confined and unconfined aquifers that have a transmissivity of less than 7,000 square feet per day (ft^2/day). Slug testing can be

performed using either a rising-head or a falling-head test. Both rising-head and falling-head tests were used at this site. The tests were performed in monitoring wells MW-16, ECS-27, ECS-30, and ECS-31 (Figure 2.1). Detailed slug testing procedures are presented in the *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater* (Wiedemeier *et al.*, 1995), hereafter referred to as the technical protocol document.

Data obtained during slug testing were analyzed using AQTESOLV® software and the methods of Bouwer and Rice (1976) and Bouwer (1989) for unconfined conditions. The results of slug testing are presented in Section 3.3 and Appendix A.

2.4 SURVEYING

After completion of field work, the locations and elevations of monitoring points, sampled monitoring wells, and soil sampling locations were surveyed by Dennis C. Drumm & Associates of Pittsfield, Massachusetts. The horizontal locations and vertical elevations of the ground surface adjacent to the sampling locations and the measurement datum (top of the PVC well/point casing, ground elevation) were measured relative to existing survey control points tied into the United States Geological Survey (USGS) 1929 coordinate system. Horizontal location was surveyed to the nearest 0.1 foot. Datum and ground surface elevations were surveyed to the nearest 0.01 foot.

SECTION 3

PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section describes the physical characteristics of Zone 1 as determined from data collected by Parsons ES in September 1996, in conjunction with data documented in previous reports on Westover ARB. Investigative techniques used by Parsons ES to determine the physical characteristics of the site are discussed in Section 2.

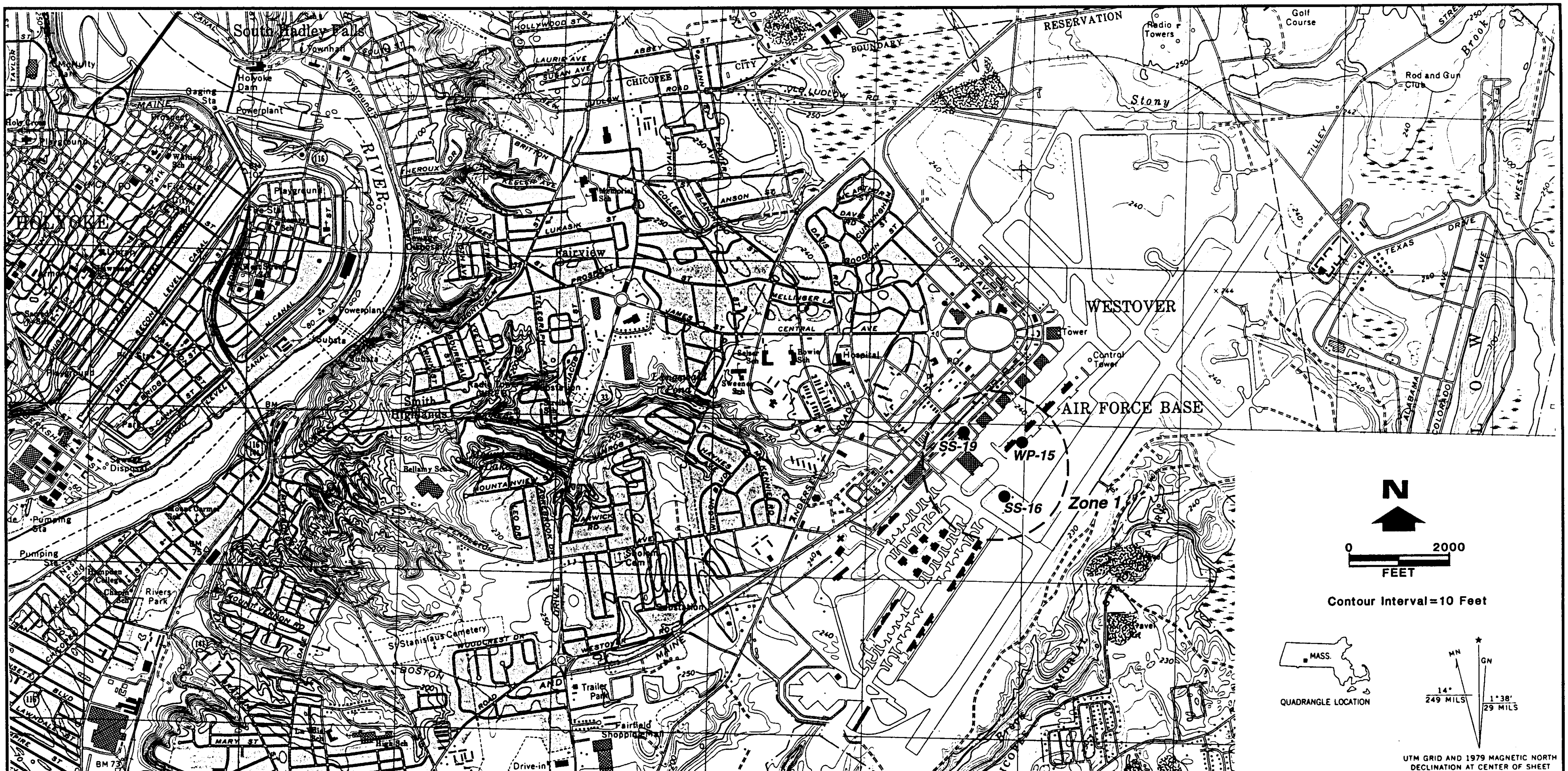
3.1 SURFACE FEATURES

3.1.1 Topography

Westover ARB is located within the Connecticut River Valley Lowland Subdivision of the New England Upland Physiographic Province, which is part of the Northern Appalachian Mountain System. The predominant topographic features of the area are the nearly level flood plains, level to gently sloping terraces along the Connecticut River, and several large intrusive dikes that rise several hundred feet above the valley floor (ES, 1988). Regional elevations range from 50 feet above mean sea level (msl) at the Connecticut River to 1,200 feet msl to the north of the Base at the summit of Mount Tom. Elevations in Zone 1 range from approximately 232 to 242 feet above msl, and the surface grade is essentially level. A topographic map of the Base and the surrounding area is presented on Figure 3.1.

3.1.2 Surface Water Hydrology

Major surface water features in the area include the Connecticut River, located approximately 2 miles west of the Base, and the Chicopee River, located approximately 1 mile south of the Base boundary. The Base is drained by three smaller drainages:



Source: USGS, 1979.

FIGURE 3.1

REGIONAL TOPOGRAPHIC BASE MAP

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Stony Brook in the north, Willomansett Brook to the west, and Cooley Brook along the southeastern boundary of the Base (Figure 3.1). Langewald Pond and Mountain Lake, west of the Base, receive water from Willomansett Brook. Cooley Brook receives runoff from most of the industrial operations, Zone 1 flight line hangars, and runways via storm sewers, culverts, and ditches. Oil/water separators have been constructed along Cooley Brook to filter storm runoff prior to discharge into the brook (OB&G, 1993). Cooley Brook supplies water to Chicopee Reservoir and the Chicopee River (approximately 1 mile south of the Base). Stony Brook, a tributary of the Connecticut River, receives runoff from the northern portion of the Base, mainly through storm drains that outfall at the brook south and east of Landfill A (OB&G, 1993).

3.1.3 Manmade Features

Zone 1 is located in an industrial portion of the Base that is used for aircraft maintenance and Base operations. Manmade features at the site include several aircraft hangers, a fuel pump house, concrete aircraft taxiways, and a parking apron (Figures 1.2 and 3.1). The primary Base runway is located on the eastern boundary of the site.

3.2 REGIONAL GEOLOGY AND HYDROGEOLOGY

Regionally, the central Massachusetts bedrock geology consists of a variety of Precambrian and early Paleozoic crystalline rocks known as the Grenville crystallines (ES, 1988). These rocks are most evident as the Adirondack Mountains to the west of the Base. The crystalline rocks underwent periods of folding, faulting, metamorphism, and intrusion during the Taconic (Ordovician) and Acadian (Devonian) orogenies. The resulting stresses from these orogenies produced extensive folding and faulting during the Mesozoic. Additional folding and rifting occurred in the early Jurassic periods, and a series of north/south-trending fault structures were formed. Unconformably overlying the crystallines are Triassic "redbeds" consisting of arkosic sandstone, conglomerates, siltstones, and occasional gray shales. The Triassic rocks in the

Westover ARB area are reddish-brown arkosic sand and siltstones of the Portland Formation. Uplift and erosion of the Triassic formations resulted in an unconformity between the Portland Formation and Pleistocene glacial sediments.

The Pleistocene glacial advance reshaped the landscape and deposited poorly sorted gravel, sand, silt, and clay mixtures as moraines and till sheets. During the glacial retreat, meltwaters impounded by glacial deposits and existing topography formed several large glacial lakes. The largest of the Pleistocene lakes in the region was glacial Lake Hitchcock, which extended from Hartford, Connecticut to Lyme, New Hampshire. The lake was as much as 250 feet deep in the Chicopee area (Thomas, 1987). The resulting sedimentation deposited thick, gray, varved lacustrine clays with silt and fine sand laminations. Overlying the lacustrine sediments are brown to gray, fine to coarse sands with traces of gravel and silt. These sediments are deltaic outwash deposits that formed as glacial Lake Hitchcock drained and filled with sediment.

The regional hydrogeology of the Westover ARB area consists of three major hydrogeologic units. An aquitard composed of lacustrine deposits and till separates the shallow, unconfined, deltaic outwash aquifer from the underlying Triassic bedrock aquifer. Both aquifers are used to a limited extent for industrial, municipal, and domestic purposes (OB&G, 1993). Because of the thick aquitard, it is considered unlikely that site contaminants in the shallow aquifer could adversely impact the Triassic bedrock aquifer. The glacial outwash aquifer ranges in thickness from 25 to 85 feet in the area of the Base, and is recharged by infiltration and runoff from rain and melting snow (OB&G, 1993). Depth to shallow groundwater is generally 5 to 40 feet bgs and is influenced by surface topographic features. The hydraulic conductivity for silty sands and clean sands typical of outwash deposits ranges from 0.03 to 2,800 feet per day (ft/day) (Freeze and Cherry, 1979). Pump tests performed by UNC Geotech

(1991) estimated the hydraulic conductivity of the shallow aquifer at the Base averages 13 ft/day and ranges from 2.2 to 33 ft/day.

3.3 SITE GEOLOGY AND HYDROGEOLOGY

Characterization of the geology and deltaic outwash aquifer system at Zone 1 has been the objective of several investigations. In 1982, an IRP records search was conducted by CH_2M Hill (1982). Subsequent investigations by ES (1988), UNC Geotech (1991), CEA (1991), ECS (1992), and OB&G (1994a, 1994b, 1995a, 1995b, and 1996) involved soil and soil gas sampling and the installation of more than 35 monitoring wells. As part of the current investigation, 21 boreholes were advanced at 18 locations using a Geoprobe®.

3.3.1 Lithology and Stratigraphic Relationships

The shallowest sediments at Zone 1 consist of 0.5 to 5 feet of a black, silty, fine- to coarse-grained sand, with some decaying organic matter. This unit is underlain by 5 to 15 feet of tan to brown, poorly sorted, medium to coarse alluvial sands containing gravel up to 0.75 inch in diameter. The poorly sorted sands are underlain by a well-sorted, fine-grained, silty sand that is approximately 5 to 20 feet thick. Below the silty fine sand is a tan to brown, fine- to coarse-grained sand that presumably overlies the varved silt and clay aquitard. Underlying the clay and silt deposit are the thin glacial till and Triassic bedrock units present throughout the region. The depth to the silt and clay aquitard in the northeastern portion of the site is approximately 70 feet bgs (OB&G, 1995b). The depth to bedrock at Zone 1 has not been determined.

To illustrate these stratigraphic relationships, two hydrogeologic sections were developed from subsurface data derived from logs of previously installed monitoring wells and from the September 1996 Geoprobe® investigation. Figure 3.2 shows the locations of these sections. Figure 3.3 presents hydrogeologic section A-A', which is

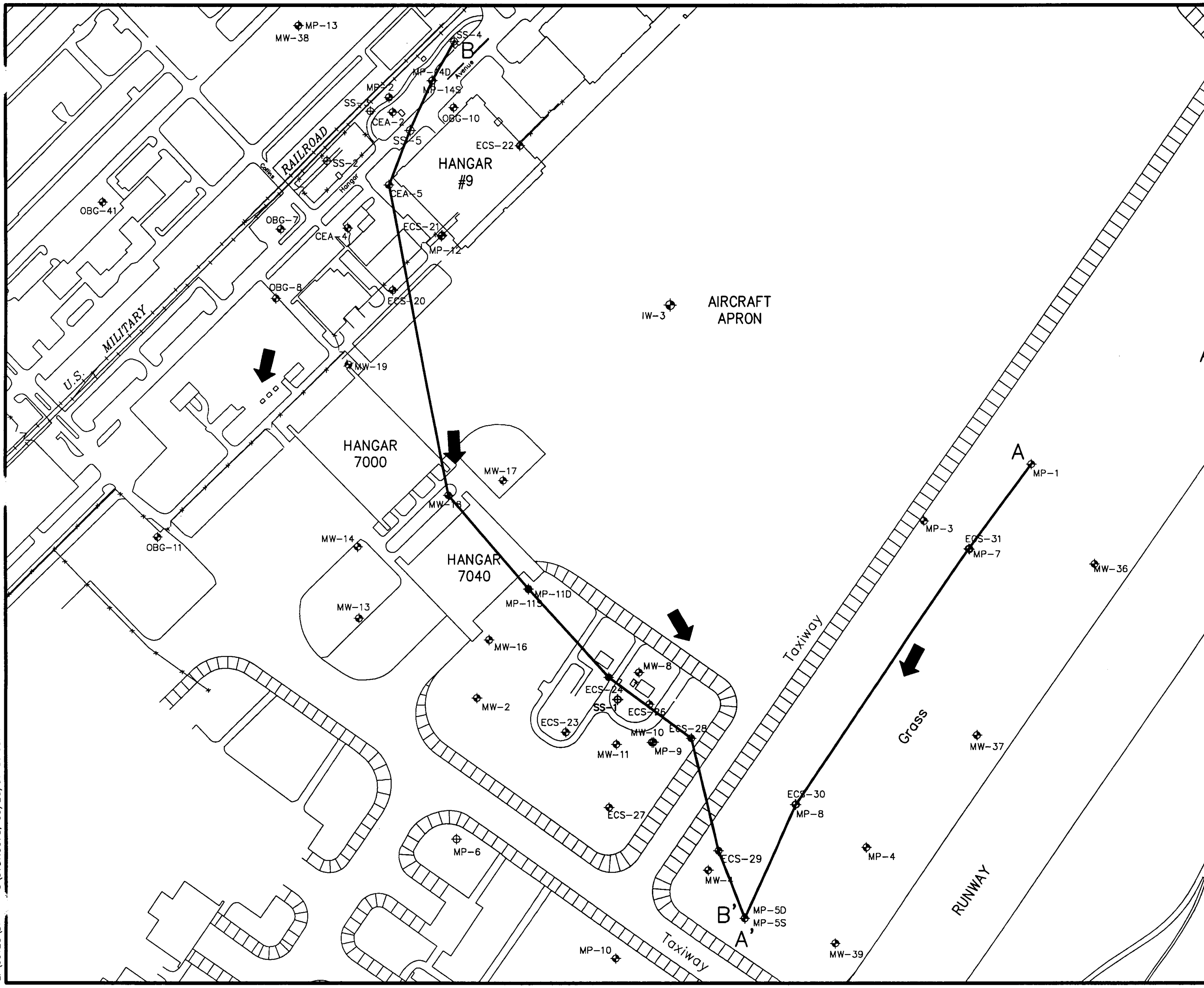


FIGURE 3.2

HYDROGEOLOGIC CROSS-SECTION LOCATIONS

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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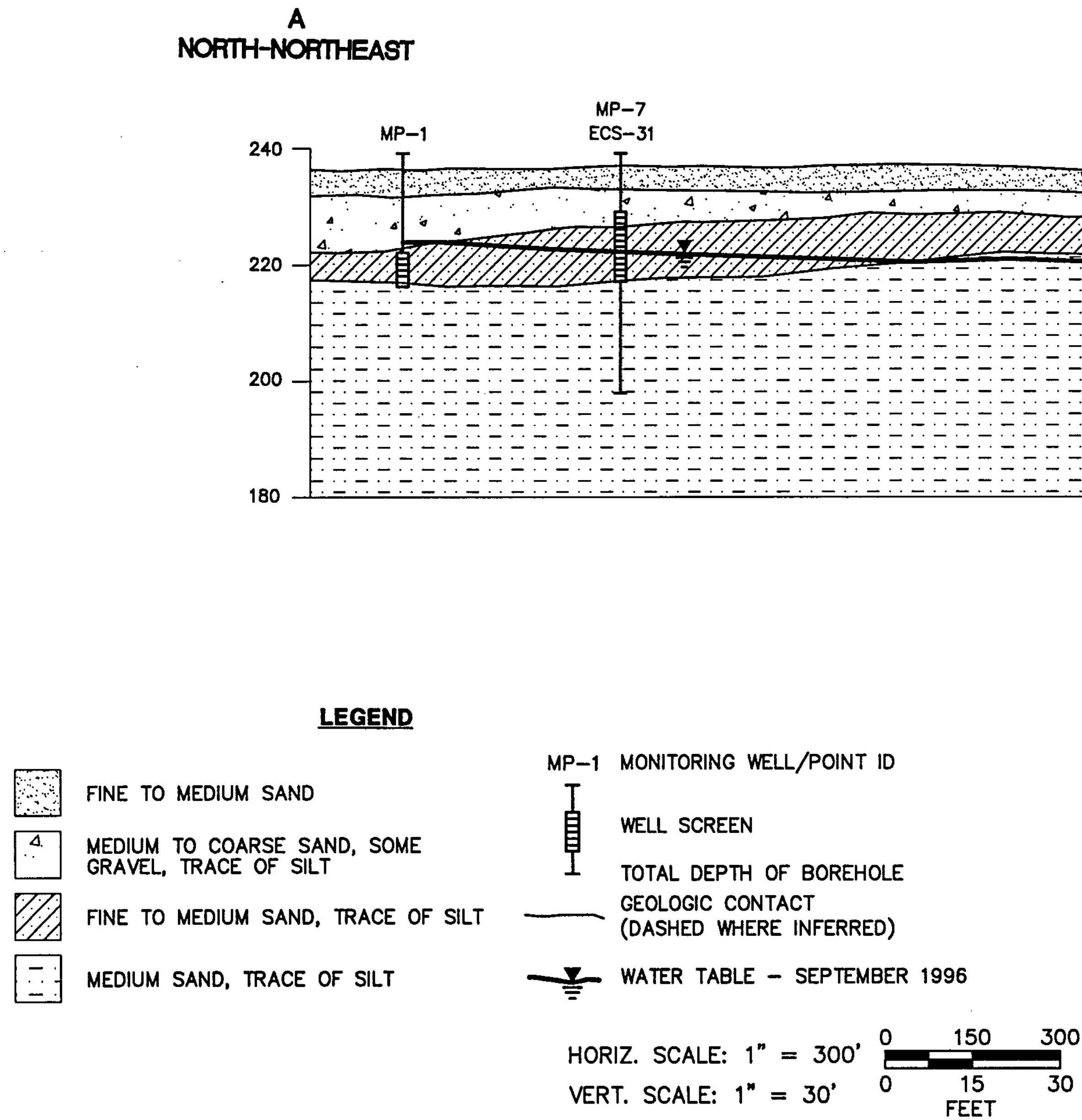

FIGURE 3.3

HYDROGEOLOGIC CROSS-SECTION A-A'

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

approximately parallel to the direction of groundwater flow on the eastern half of the site. Figure 3.4 presents hydrogeologic section B-B', which is parallel to the direction of groundwater flow in the western portion of the site.

3.3.2 Groundwater Hydraulics

3.3.2.1 Flow Direction and Gradient

The depth to groundwater is approximately 10 to 20 feet bgs across the majority of the site. A summary of groundwater elevation measurements from September 1996 is presented in Table 3.1. Across the northwestern portions of the site, groundwater flow is to the south-southeast. On the eastern side of the site, groundwater flow beneath the grassy area is to the south-southwest, excluding an anomalous groundwater elevation at well ECS-29 (Figure 3.5). The gradient at the site ranges from approximately 0.003 to 0.005 foot per foot (ft/ft).

Evidence suggests that vertical flow gradients within the shallow aquifer are present across the site. Dissolved contaminant concentrations (discussed in Section 4) suggest significant horizontal groundwater movement through the 10- to 20-foot bgs and the 35- to 50-foot bgs intervals. Given the migration of BTEX compounds to the 35- to 50-foot depth, a significant downward vertical gradient is believed to exist in the upper half of the surficial aquifer; however, this observation could not be confirmed with groundwater elevation data because all of the deep monitoring points at the site were constructed of 0.375-inch Teflon®-lined tubing, which is too narrow to allow for the measurement of groundwater elevation.

3.3.2.2 Hydraulic Conductivity

Parsons ES estimated the hydraulic conductivity at four wells screened across the water table, MW-16, ECS-27, ECS-30, and ECS-31, using falling/rising head slug tests and the method of Bouwer and Rice (1976), as described in Section 2. The results

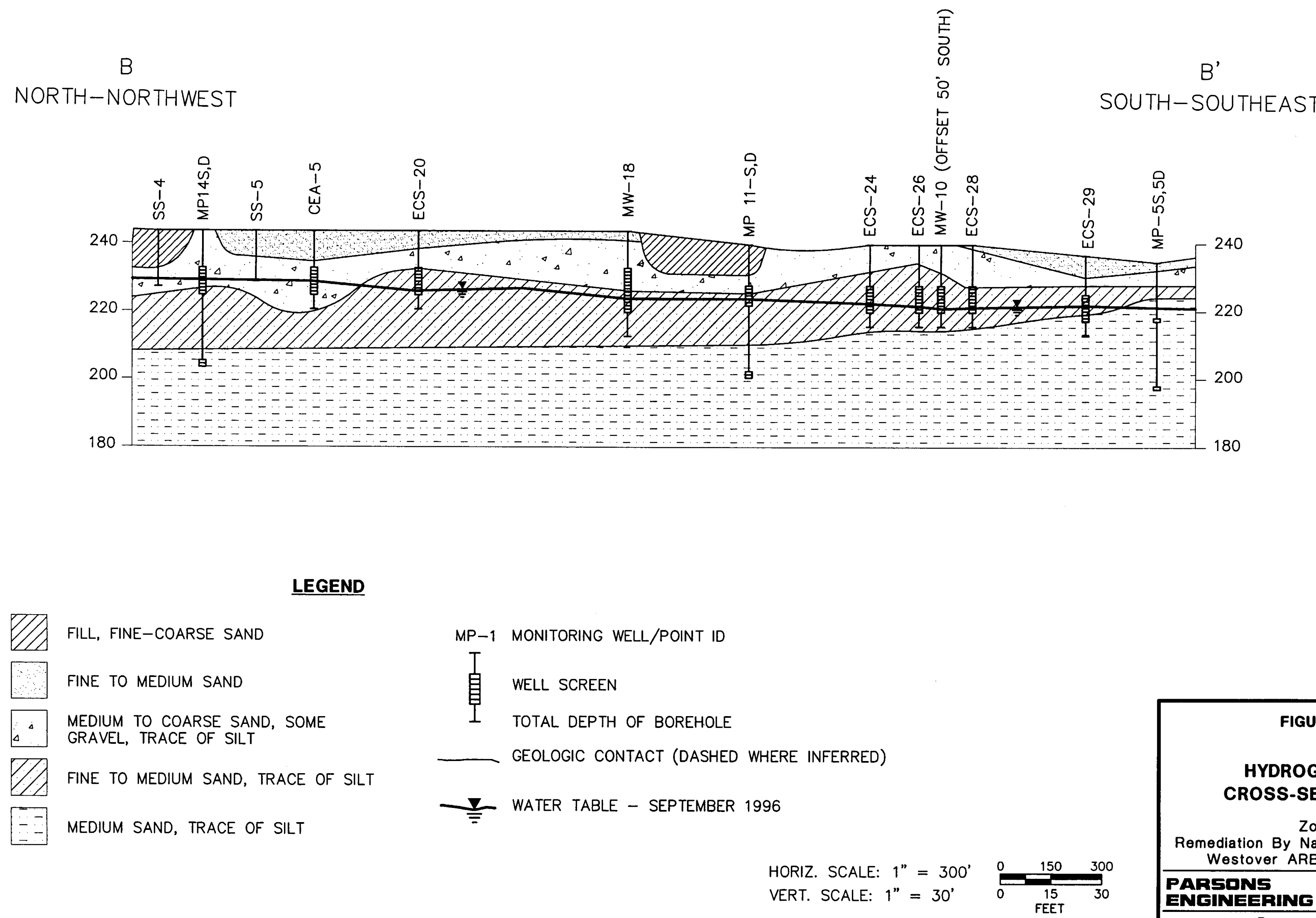

FIGURE 3.4

HYDROGEOLOGIC CROSS-SECTION B-B'

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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TABLE 3.1
SUMMARY OF GROUNDWATER LEVEL MEASUREMENTS
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Well ID	Measurement Date	Datum Elevation (ft msl) [a/]	Ground Elevation (ft msl)	Depth to Water (ft TOC) [b/]	Groundwater Elevation (ft msl)
MW-8	9/16/96	239.29	237.4	17.21	222.08
MW-11	9/16/96	238.71	236.5	17.37	221.34
MW-13	9/16/96	242.71	240.4	17.63	225.08
MW-14	9/16/96	245.26	243.0	19.29	225.97
MW-16	9/16/96	242.45	240.7	18.88	223.57
MW-19	9/16/96	244.29	242.3	16.91	227.38
MW-36	9/16/96	239.45	237.4	16.15	223.30
MW-37	9/16/96	238.97	237.2	17.30	221.67
MW-38	9/16/96	240.00	240.5	10.54	229.46
MW-39	9/16/96	238.98	237.4	21.17	217.81
ECS-20	9/16/96	242.92	241.1	16.38	226.54
ECS-22	9/16/96	245.16	243.5	16.15	229.01
ECS-23	9/16/96	238.61	236.7	17.19	221.42
ECS-24	9/16/96	240.03	238.3	18.02	222.01
ECS-26 [c/]	9/16/96	238.88	238.6	17.59	221.29
ECS-27	9/16/96	238.86	237.1	18.35	220.51
ECS-28	9/16/96	238.90	237.1	17.39	221.51
ECS-29	9/16/96	239.25	236.2	17.25	222.00
ECS-30	9/16/96	238.77	237.1	18.55	220.22
ECS-31	9/16/96	239.35	237.4	16.36	222.99
OBG-7	9/16/96	241.84	NM [d/]	12.99	228.85
OBG-8	9/16/96	242.11	NM	13.68	228.43
OBG-10	9/16/96	243.36	NM	13.65	229.71
OBG-11	9/16/96	240.44	NM	13.96	226.48
OBG-41	9/16/96	238.73	NM	10.54	228.19
CEA-2	9/16/96	242.79	NM	13.46	229.33
CEA-4	9/16/96	242.84	NM	14.11	228.73
CEA-5	9/16/96	242.04	NM	12.95	229.09
MP-1	9/16/96	237.00	237.36	13.64	223.36
MP-2	9/16/96	243.02	243.12	13.73	229.29
MP-3	9/16/96	239.89	240.05	16.62	223.27
MP-4	9/16/96	234.74	235.05	15.15	219.59
MP-10	9/16/96	238.95	239.11	21.50	217.45
MP-11S	9/16/96	240.85	240.98	16.56	224.29
MP-14S	9/16/96	242.67	242.86	13.32	229.35

a/ ft msl = feet above mean sea level.

b/ ft TOC = feet below top of casing.

c/ The depth to product was 16.81 ft below TOC and
product thickness was 0.78 ft; the corresponding corrected depth is 17.0 ft below
TOC (Corrected Depth = Measured Depth - 0.75 x Product Thickness).

d/ NM = not measured.

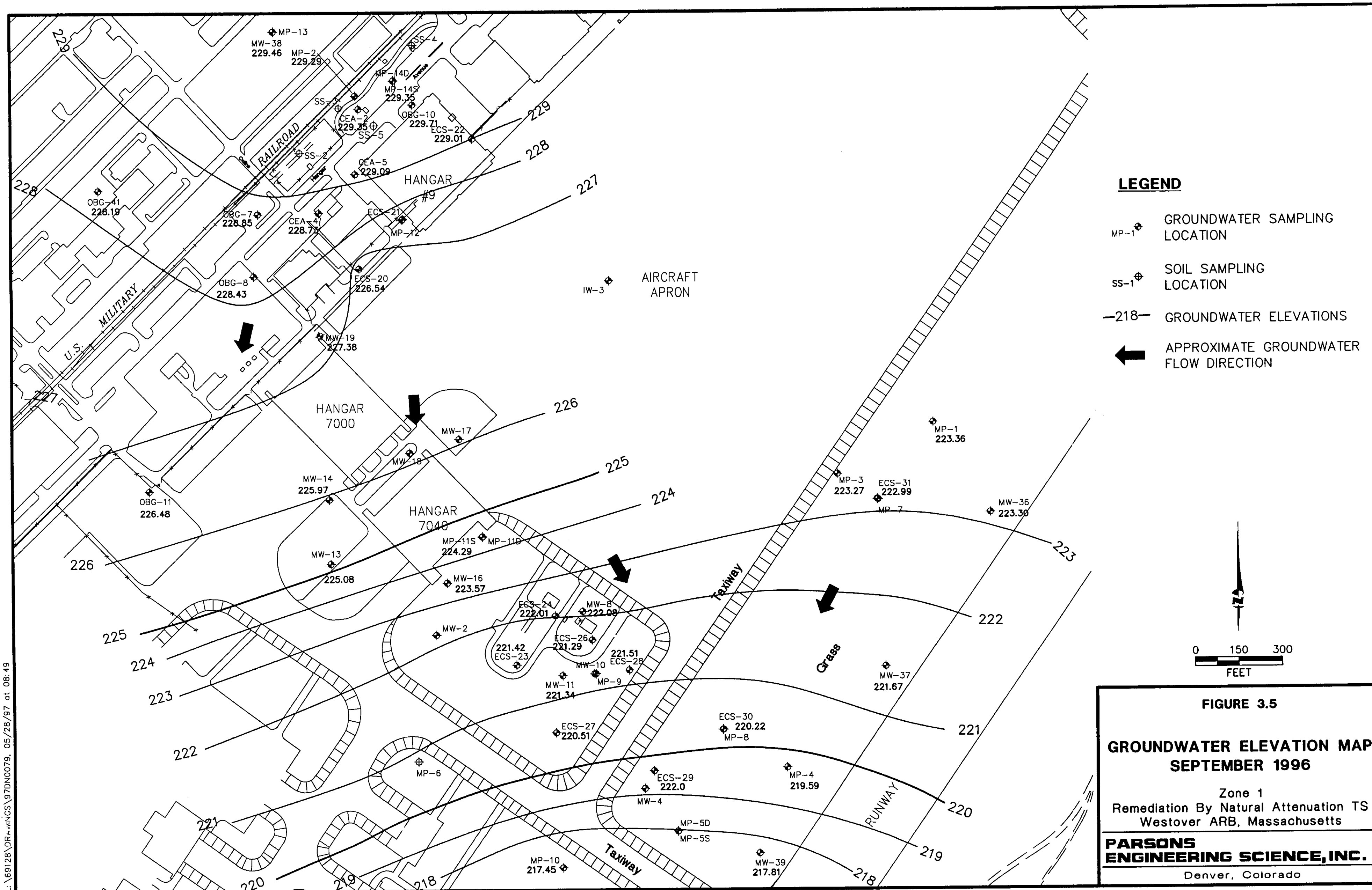

FIGURE 3.5

GROUNDWATER ELEVATION MAP SEPTEMBER 1996

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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of these slug tests are summarized in Table 3.2. Hydraulic conductivities from these four wells screened in shallow sands range from 6.7 to 63.5 ft/day, with an average hydraulic conductivity of 18.2 ft/day. An average of the hydraulic conductivity of 15 ft/day was previously estimated for the site (OB&G, 1995a). Hydraulic conductivity varies randomly across the site.

TABLE 3.2
1996 SLUG TEST RESULTS
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

WELL	HYDRAULIC CONDUCTIVITY (ft/day)	HYDRAULIC CONDUCTIVITY (ft/min)
MW-16	42	0.029
ECS-27	9.1	0.006
ECS-30	8.3	0.006
ECS-31	16	0.011
AVERAGE	18.2	0.012

3.3.2.3 Effective Porosity

Because of the difficulty involved in accurately determining effective porosity, accepted literature values for the type of soil making up the shallow saturated zone were used. Walton (1988) gives ranges of effective porosity for medium to coarse sand of 0.15 to 0.35. An average effective porosity of 0.25 was assumed for this project.

3.3.2.4 Advective Groundwater Velocity

The advective velocity of groundwater in the direction parallel to groundwater flow is given by:

$$\bar{v} = \frac{K}{n_e}\frac{dH}{dL}$$

Where: $\bar{v}$ = Average advective groundwater velocity (seepage velocity) [L/T]
K = Hydraulic conductivity [L/T] (18.2 feet per day)
dH/dL = Gradient [L/L] (0.004 ft/ft)
n_e = Effective porosity (0.25).

Using this relationship in conjunction with site-specific data and literature values, the average advective groundwater velocity at the site in May 1995, was 0.29 ft/day, or approximately 106 feet per year.

3.3.2.5 Preferential Flow Paths

No preferential contaminant migration pathways were identified during the field work phase of this project. Man-made features such as utility trenches, building foundations, or storm sewers are not believed to extend below the water table.

3.3.3 Groundwater Use

There are no known operating potable or nonpotable water wells (other than monitoring wells) located within a considerable distance from the site. There are residential areas and several trailer parks near the Base, but their water is supplied from the city water system. Some local residents rely on water from wells in the shallow unconfined aquifer, but the closest such domestic-use wells are located several miles downgradient from the site. Only one nonpotable well, located approximately 1 mile north of the site, is currently operational on the Base. All remaining wells at or near the Base have been abandoned in favor of municipal water provided by the City of Chicopee from surface water supplies.

3.4 CLIMATE

The climate in south central Massachusetts is typified by cold winters and moderately warm summers. The temperatures range from a mean high of 83 degrees Fahrenheit (°F) in July to a mean low of 16°F in January. Precipitation averages 42 inches per year, with the maximum precipitation typically occurring during the months of July through September. May is usually the driest month, with a mean precipitation total of 2.8 inches.

SECTION 4

NATURE AND EXTENT OF CONTAMINATION AND SOIL AND GROUNDWATER GEOCHEMISTRY

4.1 SOURCES OF CONTAMINATION

Several sources of contamination are present throughout Zone 1. The SS-16 area had a known spill of approximately 2,200 gallons in 1988, of which about 1,000 gallons was recovered. A former fuel pit associated with SS-16, located in the grassy area on the eastern side of Zone 1 (Figure 1.2), is also a suspected source of residual and dissolved BTEX contamination. In addition, maintenance operations at the hangars and fuel distribution at the jet fuel pumphouse may have further contributed to environmental contamination in the vicinity of SS-16. Fuel storage and distribution in the area of SS-19 also contributed to Zone 1 contamination. In 1991, 19 USTs were removed at SS-19, and soils were returned to the excavation sites. USTs at SS-19 were know to have leaked prior to 1991; however, the duration and number of leaks, and the amount of fuel lost are unknown. USTs formerly located near site WP-15, a former wastewater treatment plant (operated from 1956 to 1988), also have been identified as potential source of soil and groundwater contamination within Zone 1.

On the basis of previous investigations these source areas are known to have impacted site groundwater with dissolved BTEX contamination; however, limited soil sampling during previous investigations did not fully define the extent of soil contamination associated with each of the sources. Prior to the field work for this TS, mobile LNAPL has not been observed throughout Zone 1 in recent years (OB&G, 1996); however, in September 1996, approximately 0.78 foot of mobile LNAPL was measured in monitoring well ECS-26 at SS-16.

4.2 SOURCE AND SOIL CHEMISTRY

Residual LNAPL is defined as the LNAPL that is trapped in the aquifer by the processes of cohesion and capillarity, and therefore, will not flow within the aquifer or from the aquifer matrix into a well under the influence of gravity. Mobile LNAPL is defined as LNAPL that is free to flow in the aquifer and will flow from the aquifer matrix into a well under the influence of gravity. At this site, the residual LNAPL consists of fuel hydrocarbons derived from JP-4. The following sections describe the residual LNAPL contamination found at the site. Mobile LNAPL observed in monitoring well ECS-26 was not characterized during this investigation.

4.2.1 Soil BTEX and Fuel Hydrocarbon Contamination

In 1993, 12 soil borings were installed at SS-19 by A&W Environmental Drilling under the direction of OB&G (1994a). Split-spoon samples were collected from depths up to 25 feet bgs and screened in the field for organic vapors using a PID. Soil samples were also submitted for laboratory analysis for inorganics, total petroleum hydrocarbons (TPH), and VOCs. The analytical results for soil samples from the SS-19 soil borings indicate that BTEX and other petroleum hydrocarbons are present at locations corresponding to the former fuel USTs. Total BTEX concentrations of up to 89,700 micrograms per kilogram (µg/kg) were detected in soil samples collected near the water table (at approximately 13 to 15 feet bgs). The soil sample from the 0- to 2-foot interval in soil borehole SB-11 had a BTEX concentration of 3.2 µg/kg, and was the only soil sample from above the water table in which any BTEX compounds were detected. TPH were detected in soil samples from all sampled intervals at concentrations ranging from 2.3 milligrams per kilogram (mg/kg) in the 3- to 5-foot soil sample from boring SB-2 to 1,100 mg/kg in the 3- to 5-foot sample from soil boring SB-7. Soil borehole SB-7 is located adjacent to the former location of the easternmost USTs (Figure 2.2). In general, the data indicate that soil contamination in the UST areas of site SS-19 is widespread, with relatively higher concentrations of TPH near the eastern edge of the site. Appendix B contains a summary of sampling

locations and soil analytical data from these efforts. Appendix B also presents maps describing the soil sampling results from the OB&G (1995b) investigation.

In 1986, ES drilled and sampled two shallow test borings (IWS-1 and IWS-2) to depths of 20 feet bgs near the former USTs at site WP-15. Soil samples were analyzed for halogenated and aromatic VOCs and TPH. The only CAH detected in soil was dichloromethane at concentrations ranging from 1.1 μg/kg to 1.8 μg/kg in the 10- to 20-foot bgs interval. Results indicate TPH levels of less than 0.5 mg/kg in soil samples from the 10- to 20-foot bgs interval (ES, 1988).

At SS-16, ES (1988) collected soil samples for TPH analysis from 28 soil borings located beneath and adjacent to the site of Hangar 7040, prior to construction. TPH were detected at a concentration of 480 mg/kg in only one of these samples, which was collected near what is now the southeastern edge of Hanger 7040. The remaining samples had no TPH above the detection limit (100 mg/kg). A map of the ES sampling locations is presented in Appendix B.

In September 1996, 15 soil samples were collected from 13 locations at Zone 1. Analytical result for these oil samples are presented in Table 4.1. Of the nine soil samples analyzed for BTEX and TMB compounds, detectable concentrations of contamination were found only in samples taken from MP-2, SS-1, SS-2, and SS-4. Benzene, ethylbenzene, and 1,3,5-TMB were not detected in any soil samples taken from Zone 1; therefore, the low detected soil contaminant levels found consisted of toluene, xylenes, and 1,2,4- and 1,2,3-TMBs. Detected fuel hydrocarbon concentrations all were less than 5 μg/kg. Current soil results suggest that residual LNAPL in the vadose zone is not a significant source for dissolved BTEX contamination at Zone 1.

4.2.2 Total Organic Carbon

TOC concentrations are used to estimate the amount of organic matter sorbed to soil particles or trapped in the interstitial passages of a soil matrix. The TOC concentration

TABLE 4.1
1996 SOIL ANALYTICAL DATA
ZONE 1
REMEDIATION BY NATURAL ATTENUATION
WESTOVER AFB, MASSACHUSETTS

Sample ID	Date Sampled	Depth (feet bgs)	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Total Xylenes (mg/kg)	Total BTEX (mg/kg)	1,3,5-TMB (mg/kg)	1,2,4-TMB (mg/kg)	1,2,3-TMB (mg/kg)	TPH (mg/kg)	TOC (%)
MP-1	9/10/96	15.0	ND[a/]	ND	ND	ND	ND	ND	ND	ND	NA	ND
MP-2	9/10/96	14.0	ND	0.5	ND	0.7	1.2	ND	ND	ND	ND	0.55
MP-3	9/11/96	16.5	NA[b/]	NA	NA	NA	NA	NA	NA	NA	NA	ND
MP-4	9/11/96	15.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND
MP-6	9/11/96	15.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND
MP-10	9/13/96	21.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND
MP-11	9/14/96	16.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND
MP-14	9/14/96	16.5	ND	ND	ND	ND	ND	ND	ND	0.8	NA	ND
SS-1	9/15/96	14.5	ND	1.3	ND	1.4	2.7	ND	0.8	ND	ND	ND
SS-2	9/15/96	13.5	ND	0.8	ND	0.4	1.2	ND	ND	0.6	ND	0.20
SS-3	9/15/96	8.5	ND	ND	ND	ND	ND	ND	ND	0.5	ND	NA
SS-3	9/15/96	13.0	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND
SS-4	9/15/96	13.0	ND	1.2	ND	0.7	1.9	ND	ND	ND	ND	0.23
SS-5	9/15/96	4.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SS-5	9/15/96	7.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

[a/] ND = Not detected.
[b/] NA = Not analyzed.

in the saturated zone is an important parameter used to estimate the amount of contaminant that could potentially be sorbed to the aquifer matrix. Sorption results in retardation of the contaminant plume relative to the average advective groundwater velocity. In addition, TOC can be used as a gross indicator of organic compounds that are available as a source of carbon and electrons (i.e., substrate) for microbial activity.

Thirteen of the soil samples collected by Parsons ES in September 1996 were analyzed for TOC. The samples were taken at or near the groundwater interface and used to estimate contaminant retardation as a result of sorption. TOC results range from <0.05 to 0.55 percent (Table 4.1). Petroleum hydrocarbon (fuel) contamination is present in soils at Zone 1, and it is not known whether fuel-contaminated soils were sampled for TOC analysis, resulting in elevated TOC values. In fact, all TOC concentrations above <0.05 percent were measured in samples that also had BTEX contamination; therefore, the average TOC concentration for the samples containing no detected BTEX was <0.05 percent.

4.3 GROUNDWATER CHEMISTRY

Three lines of evidence can be used to document the occurrence of natural attenuation: 1) geochemical evidence; 2) documented loss of contaminant mass at the field scale; and 3) laboratory microcosm studies. Geochemical evidence is used herein to support the occurrence of natural attenuation, as described in the following sections. The loss of contaminant mass is calculated and modeled in Section 5. Because these two lines of evidence strongly suggest that natural attenuation is occurring at this site, laboratory microcosm studies were not deemed necessary.

4.3.1 Dissolved Hydrocarbon and Chlorinated Solvent Contamination

Groundwater samples were collected in 1988, 1989, 1991, 1993, 1994, 1995, and 1996 and analyzed for one or more of the following suites of analytes: BTEX, TPH, metals, total dissolved solids, VOCs, and semivolatile organic compounds (SVOCs). A

summary of the previous laboratory analytical results for groundwater samples from Zone 1 is presented in Appendix B.

The highest BTEX concentrations were detected in groundwater samples collected at wells CEA-5 and MW-10, with reported concentrations of 28,600 μg/L in January 1994, and 25,200 μg/L in December 1988, respectively. CEA-5 is located about 150 feet downgradient from the former USTs at SS-19. MW-10 is located within the source area at SS-16. In groundwater samples from monitoring well IW-3 at the WP-15 portion in Zone 1, the maximum BTEX concentrations decreased from 122 μg/L in July 1993 to 38 μg/L in February 1996. Data from the February 1996 sampling round indicate the maximum total BTEX concentrations at SS-16 and SS-19 were approximately 6,700 μg/L and 19,300 μg/L in groundwater samples from wells MW-11 and CEA-5, respectively (OB&G, 1996).

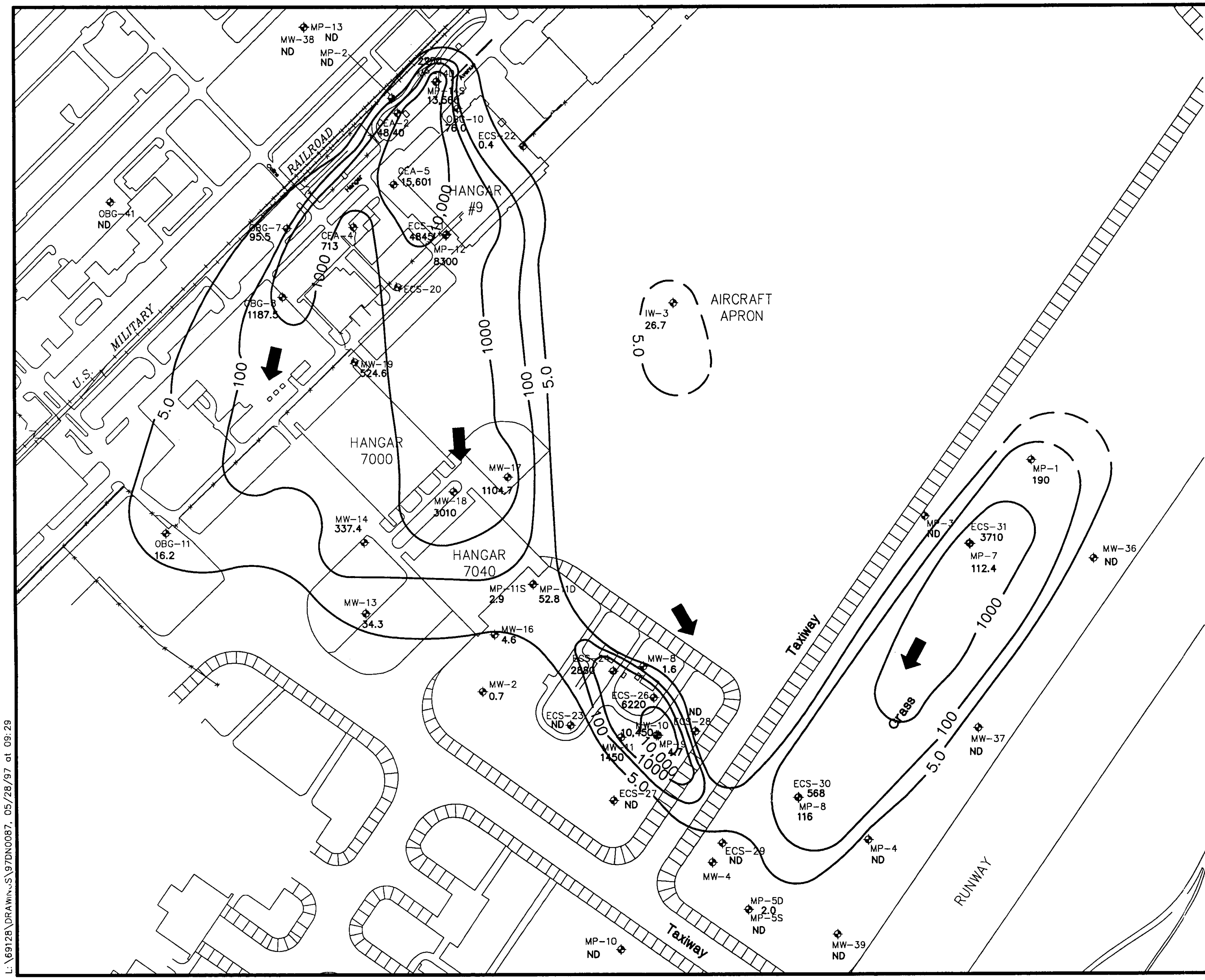
The BTEX results correlate well among sampling events. The data generally suggest that the total BTEX concentrations are decreasing or stable in Zone 1. Between sampling rounds in March 1991 and January 1994, BTEX concentrations increased in groundwater samples from monitoring wells located in the source area at SS-19 (i.e., CEA-1, -3, and -5). During the period from January 1994 to February 1996, the BTEX concentrations decreased from 28,600 μg/L to 19,322 μg/L at monitoring well CEA-5. In September 1996, the BTEX concentration at this well was 15,601 μg/L. Wells CEA-1 and CEA-3 were destroyed sometime between January 1994 and February 1996. At the remaining monitoring wells for which there are data from multiple sampling events, BTEX concentrations have remained approximately the same or decreased. The dissolved BTEX concentrations at monitoring well ECS-27, which is located downgradient from all of the Zone 1 source areas, decreased from 3,160 μg/L in January 1994, to 34 μg/L in December 1995, to nondetected in September 1996. At monitoring well ECS-31, near the former fuel pit associated with site SS-16, the BTEX concentration in groundwater samples decreased from 9,290 μg/L in January

1994 to 3,535 μg/L in February 1996. The September 1996 BTEX concentration at his well was 3,710 μg/L.

Historically, chlorinated VOCs also have been detected in groundwater samples at Zone 1. However, with the exception of monitoring wells IW-3, IW-4, and MW-13, all the detectable concentrations have been reported as estimated by the analytical laboratory. Furthermore, at wells IW-3, IW-4, and MW-13, concentrations of dissolved CAHs have decreased with time. Appendix B contains a table summarizing the chlorinated solvent analytical results from previous groundwater investigations. The highest chlorinated solvent concentrations have been detected in samples from monitoring well IW-3, associated with the WP-15 portion of Zone 1. At IW-3, the concentration of the most prevalent chlorinated solvent, 1,2-DCE, decreased from 800 μg/L in July 1994 to 550 μg/L in February 1996. TCE concentrations at IW-3 also decreased during this time period. Beyond the WP-15 portion of Zone 1, chlorinated solvent concentrations have been low in concentration and very limited in extent. In the July 1994 samples from well MW-13, the TCE and 1,2-DCE concentrations were 5.9 μg/L and 22 μg/L, respectively. In February 1996, only TCE was detected, at a concentration of 0.2 μg/L. In groundwater samples from monitoring wells CEA-4, CEA-6, ECS-31, ECS-32, MW-19, and MW-38, the only detected compound, methylene chloride, also was detected in the laboratory blank sample, indicating probable laboratory contamination.

4.3.1.1 Dissolved BTEX Contamination

In September 1996, groundwater samples were collected from 33 of the 45 previously installed monitoring wells and from 16 newly installed groundwater monitoring points. The areal distribution of total dissolved BTEX in groundwater for September 1996 is presented on Figure 4.1. At nested monitoring points or wells, isopleths are drawn using the maximum concentration detected at that location. For September 1996, as indicated by the 5-μg/L isopleth, the BTEX plume originating from SS-19 is approximately 1,800 feet long and 1,200 feet wide. At SS-16, two distinct



LEGEND

MP-1 — MONITORING LOCATION WITH TOTAL DISSOLVED BTEX CONCENTRATION ($\mu g/L$)

5 — LINE OF EQUAL DISSOLVED BTEX CONCENTRATION ($\mu g/L$) (DASHED WHERE INFERRED)

ND — NOT DETECTED

APPROXIMATE GROUNDWATER FLOW DIRECTION

NOTE:
WHERE MULTIPLE SAMPLES WERE COLLECTED AT THE SAME LOCATION, THE MAXIMUM CONCENTRATION WAS USED FOR ISOPLETH CONSTRUCTION.

N

0 150 300
FEET

FIGURE 4.1

TOTAL BTEX IN GROUNDWATER ISOPLETH MAP SEPTEMBER 1996

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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dissolved contaminant plumes are visible, one plume approximately 750 feet by 300 feet is related to the fuel storage yard, and another plume approximately 1,650 feet long by 450 feet wide, is related to a fuel pit or fuel transfer lines that run along the taxiway. The extent of dissolved BTEX contamination at WP-15 is currently undefined in the source area; however, the contamination plume does not extend beyond the SS-19 and SS-16 plumes that merge on the south side of Zone 1. Overall the area of BTEX-contaminated groundwater at Zone 1 is approximately 264,000 square feet, or approximately 6 acres.

The vertical distributions of total dissolved BTEX in September 1996 remain undefined, although a clay/silt aquitard exists approximately 50 below the water table. The low horizontal groundwater gradient at the site reduces the horizontal groundwater velocity, and therefore, BTEX compounds migrate or disperse in groundwater both horizontally and vertically. On the basis of the analytical results from the September 1996 and prior sampling events, the maximum depth of the dissolved BTEX contamination is estimated to approximately coincide with the contact between the medium sand glacial outwash aquifer and the clay/silt aquitard. Vertical profiles are not included in this report because of limited groundwater data below 40 feet bgs.

Total dissolved BTEX concentrations have decreased throughout Zone 1 since 1988. In September 1996, the highest dissolved total BTEX of 15,601 μg/L was observed in CEA-5, located in area SS-19 (Table 4.2). This concentration represents a 20-percent decrease since February 1996, and a 45-percent decrease since January 1994. At SS-16, the highest dissolved BTEX concentration was 10,450 μg/L, observed at MW-10. Similar to CEA-5 concentrations at SS-19, the 10,450-μg/L total BTEX concentration at MW-10 represents a decrease in contamination of more than 50 percent since 1988. At the second SS-16 source area near the fuel pit, dissolved BTEX concentrations have decreased approximately 60 percent since 1994, to a current concentration of 3,710 μg/L.

TABLE 4.2
GROUNDWATER QUALITY DATA SUMMARY
FOR BTEX, TMBs, AND FUEL CARBON
ZONE 1
REMEDIATION BY NATURAL ATTENUATION
WESTOVER AFB, MASSACHUSETTS

Sample ID	Date Sampled	Benzene (μg/L)	Toluene (μg/L)	Ethyl-Benzene (μg/L)	Total Xylenes (μg/L)	Total BTEX (μg/L)	1,3,5-TMB (μg/L)	1,2,4-TMB (μg/L)	1,2,3-TMB (μg/L)	Fuel Carbon (mg/L)
CEA-2	9/10/96	ND[a/]	1000	640.0	3200.0	4840.0	110.0	380.0	130.0	ND
CEA-4	9/12/96	ND	23.0	160.0	530.0	713.0	3.6	18.0	4.5	2.7
CEA-5	9/11/96	41.0	11000.0	760.0	3800.0	15601.0	ND	210.0	61.0	27.0
ECS-20	9/14/96	35.0	1300.0	710.0	2800.0	4845.0	130.0	290.0	77.0	12.0
ECS-22	9/14/96	ND	0.4	ND	ND	0.4	ND	ND	ND	ND
ECS-23	9/13/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
ECS-24	9/11/96	ND	370.0	410.0	2100.0	2880.0	140.0	380.0	220.0	7.4
ECS-26	9/12/96	ND	1000.0	720.0	4500.0	6220.0	210.0	490.0	290.0	21.0
ECS-27	9/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
ECS-28	9/13/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
ECS-29	9/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
ECS-30	9/11/96	30.0	350.0	58.0	130.0	568.0	8.5	23.0	14.0	2.2
ECS-31	9/10/96	ND	150.0	660.0	2900.0	3710.0	170.0	410.0	240.0	5.7
IW-3	9/13/96	ND	8.7	2.0	16.0	26.7	26.0	110.0	57.0	5.3
MP-1	9/12/96	30.0	ND	50.0	110.0	190.0	ND	72.0	57.0	1.7
MP-2	9/13/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-3	9/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-4	9/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-5D	9/12/96	ND	ND	0.8	1.2	2.0	1.6	2.9	ND	ND
MP-5S	9/12/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-7	9/12/96	110.0	ND	ND	2.4	112.4	ND	1.1	1.2	0.3
MP-8	9/12/96	49.0	16.0	22.0	29.0	116.0	3.7	8.3	13.0	1.5
MP-9	9/13/96	ND	1.8	0.8	2.1	4.7	2.1	3.2	11.0	0.5
MP-10	9/13/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-11D	9/15/96	34.0	2.1	8.9	7.8	52.8	9.3	25.0	4.2	1.5

TABLE 4.2 (Concluded)
GROUNDWATER QUALITY DATA SUMMARY
FOR BTEX, TMBs, AND FUEL CARBON
ZONE 1
REMEDIATION BY NATURAL ATTENUATION
WESTOVER AFB, MASSACHUSETTS

Sample ID	Date Sampled	Benzene (μg/L)	Toluene (μg/L)	Ethyl-Benzene (μg/L)	Total Xylenes (μg/L)	Total BTEX (μg/L)	1,3,5-TMB (μg/L)	1,2,4-TMB (μg/L)	1,2,3-TMB (μg/L)	Fuel Carbon (mg/L)
MP-11S	9/15/96	ND	1.8	1.1	ND	2.9	ND	ND	1.5	ND
MP-12	9/15/96	2100	300	1000	4900	8300.0	43	140	42	13
MP-13	9/15/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MP-14D	9/15/96	ND	460	290	1500	2250.0	12	23	9.9	3.8
MP-14S	9/15/96	ND	10000	560	3000	13560.0	30	39	13	25
MW-2	9/14/96	ND	ND	0.7	ND	0.7	ND	ND	ND	ND
MW-8	9/13/96	ND	ND	0.5	1.1	1.6	ND	ND	ND	ND
MW-10	9/11/96	1800	5500	550	2600	10450.0	140	370	210	18
MW-11	9/11/96	ND	500	160	790	1450.0	43	140	90	1.5
MW-13	9/14/96	1.5	3.8	15	14	34.3	0.9	4.6	0.9	0.5
MW-14	9/14/96	8.4	15	84	230	337.4	4	25	10	3
MW-16	9/14/96	3	ND	ND	1.6	4.6	ND	ND	ND	0.1
MW-17	9/13/96	4.7	20	150	930	1104.7	35	68	14	4.2
MW-18	9/14/96	200	1900	170	740	3010.0	22	57	11	11
MW-19	9/14/96	7.6	47	90	380	524.6	4.8	19	8	3.7
MW-36	9/10/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-37	9/11/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-38	9/10/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW-39	9/11/96	ND	ND	ND	ND	ND	ND	ND	ND	ND
OBG-7	9/14/96	ND	1.5	25.0	69.0	95.5	3	5.3	1.7	0.8
OBG-8	9/15/96	ND	5.7	250.0	930.0	1185.7	33	82	13	3.5
OBG-10	9/15/96	ND	9.0	15.0	52.0	76.0	9.2	18	9	0.9
OBG-11	9/14/96	0.5	11.0	0.9	3.8	16.2	ND	ND	ND	ND
OBG-41	9/10/96	ND	ND	ND	ND	ND	ND	ND	ND	ND

[a] ND = not detected.

022/729691/WESROVER/11.XLS/Table 4.2 10:28 AM 5/23/97

Groundwater samples from monitoring well IW-3 at the WP-15 portion of Zone 1 have also shown a general decreasing trend in total dissolved BTEX concentrations. The maximum BTEX concentrations decreased from 122 μg/L in July 1993, to 38 μg/L in February 1996, to 26.7 μg/L in September 1996.

Total xylenes comprised approximately 44 percent of the dissolved BTEX contamination observed in groundwater at Zone 1. Dissolved toluene at Zone 1 was approximately 41 percent of total dissolved BTEX contamination. Observed dissolved benzene and ethylbenzene were 5.4 and 9.2 percent of total dissolved BTEX concentrations in groundwater at Zone 1, respectively. These ratios do not provide conclusive information that one or more of the BTEX compounds in being preferentially degraded; rather, the ratios correspond to the relative BTEX fraction in JP-4. In other words, toluene and xylenes make up a larger portion of the dissolved contamination because they make up a larger percentage of the fuel originally spilled at the site. This and solubility limits in turn enable more toluene and xylenes to be dissolved in groundwater than benzene or ethylbenzene.

4.3.1.2 Dissolved Chlorinated Solvent Contamination

In September 1996, groundwater samples from three monitoring wells and four monitoring points were analyzed for dissolved chlorinated solvent contamination. The concentrations of individual chlorinated solvents are presented in Table 4.3. The source of CAH appears to be just upgradient from IW-3, at WP-15 within Zone 1. Total chlorinated solvent concentrations at IW-3 are 408.5 μg/L, which represents more than a 50-percent decrease since 1993. Of the detected chlorinated solvents, *cis*-1,2-DCE accounted for more than 95 percent of total dissolved CAHs observed in the sample collected from IW-3; PCE, TCE and vinyl chloride account for the remaining 5 percent. Further downgradient, TCE (28.0 μg/L) and *cis*-1,2-DCE (9.2 μg/L) were observed at MP-11D. *cis*-1,2-DCE at 2.3 μg/L was observed at MP-11S. Estimated concentrations of 1,1-DCE in samples taken from IW-3 and MP-5D are thought to be

TABLE 4.3
GROUNDWATER QUALITY DATA SUMMARY FOR CHLORINATED VOLATILE ORGANIC COMPOUNDS
ZONE 1
REMEDIATION BY NATURAL ATTENUATION
WESTOVER AFB, MASSACHUSETTS

Sample Identification	Date Sampled	PCE (mg/L)	TCE (mg/L)	1,1-DCE (mg/L)	Trans-1,2-DCE (mg/L)	Cis-1,2-DCE (mg/L)	Vinyl Chloride (mg/L)
IW-3	9/13/96	13	4.1	0.51 J,X[a/]	ND[b/]	390.0	1.4
MP-5D	9/12/96	ND	ND	0.42 J,X	ND	ND	ND
MP-9	9/13/96	ND	ND	ND	ND	ND	ND
MP-11S	9/15/96	ND	ND	ND	ND	2.3	ND
MP-11D	9/15/96	ND	28.0	ND	ND	9.2	ND
MW-13	9/14/96	ND	ND	ND	ND	ND	ND
MW-17	9/13/96	ND	ND	ND	ND	ND	ND

[a/] J,X = Estimated concentration, compound also detected in reagent blank.

[b/] ND = Not detected.

linked to laboratory cross-contamination (1,1-DCE was detected in the reagent blank), and therefore are not discussed further in this TS.

In addition to a general decrease in concentration at IW-3, the mix of solvents dissolved in groundwater have shifted over time. In August 1993, *cis*-1,2-DCE accounted for 83 percent of the total detected chlorinated solvents at IW-3, and PCE accounted for the remaining 17 percent. TCE, trans-DCE, and vinyl chloride were not detected at IW-3 during this sampling event. In August 1994, the percentage of *cis*-1,2-DCE increased to 88, PCE decreased to 11 percent, and TCE was the remaining 1 percent of the total observed chlorinated solvents at monitoring well IW-3. Percentages of chlorinated solvent contamination at IW-3 remained similar from 1994 to early 1996; however, in September 1996 data suggest that trends toward higher percentages of lesser chlorinated solvents resumed. In September 1996, *cis*-1,2-DCE represents more than 95 percent of total chlorinated solvent contamination; PCE, TCE and vinyl chloride represent 3.2 percent, 1 percent, and 0.3 percent, respectively. This was the first observation of vinyl chloride in IW-3. Interpretation of these trends with respect to biodegradation of chlorinated solvents is discussed in Section 4.3.3.

4.3.2 Biodegradation of Fuel Hydrocarbons

Numerous laboratory and field studies have shown that hydrocarbon-degrading bacteria can participate in the degradation of many of the chemical components of jet fuel and gasoline, including the BTEX compounds (e.g., Jamison *et al.*, 1975; Atlas, 1981, 1984, 1988; Gibson and Subramanian, 1984; Reinhard *et al.*, 1984; Young, 1984; Bartha, 1986; Wilson *et al.*, 1986, 1987, and 1990; Barker *et al.*, 1987; Baedecker *et al.*, 1988; Lee, 1988; Chiang *et al.*, 1989; Grbic-Galic, 1989 and 1990; Cozzarelli *et al.*, 1990; Leahy and Colewell, 1990; Altenschmidt and Fuchs, 1991; Alvarez and Vogel, 1991; Baedecker and Cozzarelli, 1991; Ball *et al.*, 1991; Bauman, 1991; Borden, 1991; Brown *et al.*, 1991; Edwards *et al.*, 1991 and 1992; Evans *et al.*, 1991a and 1991b; Haag *et al.*, 1991; Hutchins and Wilson, 1991; Hutchins *et al.*, 1991a and 1991b; Beller *et al.*, 1992; Bouwer, 1992; Edwards and Grbic-Galic, 1992;

Thierrin *et al.*, 1992; Malone *et al.*, 1993; Davis *et al.*, 1994). Biodegradation of fuel hydrocarbons can occur when an indigenous population of hydrocarbon-degrading microorganisms is present in the aquifer and sufficient concentrations of electron acceptors and nutrients, including fuel hydrocarbons, are available to these organisms.

Microorganisms obtain energy for cell production and maintenance by facilitating thermodynamically advantageous reduction/oxidation (redox) reactions involving the transfer of electrons from electron donors to available electron acceptors. This results in the oxidation of the electron donor and the reduction of the electron acceptor. Electron donors at Zone 1 include natural organic carbon and fuel hydrocarbon compounds. Fuel hydrocarbons are completely degraded or detoxified if they are utilized as the primary electron donor for microbial metabolism (Bouwer, 1992). Electron acceptors are elements or compounds that occur in relatively oxidized states, and include DO, nitrate, ferric iron, sulfate, and carbon dioxide.

The driving force behind BTEX degradation is electron transfer, quantified by the Gibbs free energy of the reaction ($\Delta G°_r$) (Stumm and Morgan, 1981; Bouwer, 1994; Godsey, 1994). The value of $\Delta G°_r$ represents the quantity of free energy consumed or yielded to the system during the reaction. Table 4.4 lists stoichiometry of the redox equations involving BTEX and the resulting $\Delta G°_r$. Although thermodynamically favorable, most of the reactions involved in BTEX oxidation cannot proceed abiotically because of the lack of activation energy. Microorganisms are capable of providing the necessary activation energy; however, they will facilitate only those redox reactions that have a net yield of energy (i.e., $\Delta G°_r < 0$). Microorganisms preferentially utilize electron acceptors while metabolizing fuel hydrocarbons (Bouwer, 1992). DO is utilized first as the prime electron acceptor. After the DO is consumed, anaerobic microorganisms typically use electron acceptors (as available) in the following order of preference: nitrate, ferric iron hydroxide, sulfate, and finally carbon dioxide. Because the biodegradation of fuel hydrocarbons should deplete the concentrations of these electron acceptors, construction of isopleth maps depicting their concentrations can

TABLE 4.4
COUPLED OXIDATION REACTIONS FOR BTEX COMPOUNDS
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Coupled Benzene Oxidation Reactions	ΔG°_r (kcal/mole Benzene)	ΔG°_r (kJ/mole Benzene)	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$7.5O_2 + C_6H_6 \Rightarrow 6CO_{2,g} + 3H_2O$ *Benzene oxidation /aerobic respiration*	-765.34	-3202	3.07:1
$6NO_3 + 6H^+ + C_6H_6 \Rightarrow 6CO_{2,g} + 6H_2O + 3N_{2,g}$ *Benzene oxidation / denitrification*	-775.75	-3245	4.77:1
$3.75\ NO_3^- + C_6H_6 + 7.5\ H^+ + 0.75\ H_2O \Rightarrow 6\ CO_2 + 3.75\ NH_4^+$ *Benzene oxidation / nitrate reduction*	-524.1	-2193	2.98:1
$60H^+ + 30Fe(OH)_{3,a} + C_6H_6 \Rightarrow 6CO_2 + Fe^{2+} + 78H_2O$ *Benzene oxidation / iron reduction*	-560.10	-2343	21.5:1 [a/]
$7.5H^+ + 3.75SO_4^{2-} + C_6H_6 \Rightarrow 6CO_{2,g} + 3.75H_2S^o + 3H_2O$ *Benzene oxidation / sulfate reduction*	-122.93	-514.3	4.61:1
$4.5H_2O + C_6H_6 \Rightarrow 2.25CO_{2,g} + 3.75CH_4$ *Benzene oxidation / methanogenesis*	-32.40	-135.6	0.77:1 [b/]

Coupled Toluene Oxidation Reactions	ΔG°_r (kcal/mole Toluene)	ΔG°_r (kJ/mole Toluene)	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$9O_2 + C_6H_5CH_3 \Rightarrow 7CO_{2,g} + 4H_2O$ *Toluene oxidation /aerobic respiration*	-913.76	-3823	3.13:1
$7.2NO_3 + 7.2H^+ + C_6H_5CH_3 \Rightarrow 7CO_{2,g} + 7.6H_2O + 3.6N_{2,g}$ *Toluene oxidation / denitrification*	-926.31	-3875	4.85:1
$4.5NO_3^- + 9H^+ + 0.5H_2O + C_6H_5CH_3 \Rightarrow 7CO_2 + 4.5NH_4^+$ *Toluene oxidation / nitrate reduction*	-624.24	-2609	3.03:1
$72H^+ + 36FE(OH)_{3,a} + C_6H_5CH_3 \Rightarrow 7CO_2 + 36Fe^{2+} + 94H_2O$ *Toluene oxidation / iron reduction*	-667.21	-2792	21.86:1 [a/]
$9H^+ + 4.5SO_4^{2-} + C_6H_5CH_3 \Rightarrow 7CO_{2,g} + 4.5H_2S^o + 4H_2O$ *Toluene oxidation / sulfate reduction*	-142.86	-597.7	4.7:1
$5H_2O + C_6H_5CH_3 \Rightarrow 2.5CO_{2,g} + 4.5CH_4$ *Toluene oxidation / methanogenesis*	-34.08	-142.6	0.78:1 [b/]

TABLE 4.4 (Concluded)
COUPLED OXIDATION REACTIONS FOR BTEX COMPOUNDS
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Coupled Ethylbenzene Oxidation reactions	ΔG°_r (kcal/mole Ethyl-benzene)	ΔG°_r (kJ/mole Ethyl-benzene)	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$10.5O_2 + C_6H_5C_2H_5 \Rightarrow 8CO_{2,g} + 5H_2O$ *Ethylbenzene oxidation /aerobic respiration*	-1066.13	-4461	3.17:1
$8.4NO_3^- + 8.4H^+ + C_6H_5C_2H_5 \Rightarrow 8CO_{2,g} + 9.2H_2O + 4.2N_{2,g}$ *Ethylbenzene oxidation / denitrification*	-1080.76	-4522	4.92:1
$5.25NO_3^- + 10.5H^+ + 0.25H_2O + C_6H_5C_2H_5 \Rightarrow 8CO_2 + 5.25NH_4^+$ *Ethylbenzene oxidation / nitrate reduction*	-746.04	-3118	3.07:1
$84H^+ + 42Fe(OH)_{3,a} + C_6H_5CH_5 \Rightarrow 8CO_2 + 42Fe^{2+} + 110H_2O$ *Ethylbenzene oxidation / iron reduction*	-778.48	-3257	22:1[a/]
$10.5H^+ + 5.25SO_4^{2-} + C_6H_5C_2H_5 \Rightarrow 8CO_{2,g} + 5.25H_2S^\circ + 5H_2O$ *Ethylbenzene oxidation / sulfate reduction*	-166.75	-697.7	4.75:1
$5.5H_2O + C_6H_5C_2H_5 \Rightarrow 2.75CO_{2,g} + 5.25CH_4$ *Ethylbenzene oxidation / methanogenesis*	-39.83	-166.7	0.79:1 [b/]

Coupled m-Xylene Oxidation Reactions	ΔG°_r (kcal/mole *m*-xylene)	ΔG°_r (kJ/mole *m*-xylene)	Stoichiometric Mass Ratio of Electron Acceptor to Compound
$10.5O_2 + C_6H_4(CH_3)_2 \Rightarrow 8CO_{2,g} + 5H_2O$ *m-Xylene oxidation /aerobic respiration*	-1063.25	-4448	3.17:1
$8.4NO_3^- + 8.4H^+ + C_6H_4(CH_3)_2 \Rightarrow 8CO_{2,g} + 9.2H_2O + 4.2N_{2,g}$ *m-Xylene oxidation / denitrification*	-1077.81	-4509	4.92:1
$5.25NO_3^- + 10.5H^+ + 0.25H_2O + C_6H_4(CH_3)_2 \Rightarrow 8CO_2 + 5.25NH_4^+$ *m-Xylene oxidation / nitrate reduction*	-743.52	-3108	3.07:1
$84H^+ + 42Fe(OH)_{3,a} + C_6H_4(CH_3)_2 \Rightarrow 8CO_2 + 42Fe^{2+} + 110H_2O$ *m-Xylene oxidation / iron reduction*	-775.61	-3245	22:1[a/]
$10.5H^+ + 5.25SO_4^{2-} + C_6H_4(CH_3)_2 \Rightarrow 8CO_{2,g} + 5.25H_2S^\circ + 5H_2O$ *m-Xylene oxidation / sulfate reduction*	-163.87	-685.6	4.75:1
$5.5H_2O + C_6H_4(CH_3)_2 \Rightarrow 2.75CO_{2,g} + 5.25CH_4$ *m-Xylene oxidation / methanogenesis*	-36.95	-154.6	0.79:1 [b/]

[a/] Mass of ferrous iron produced during microbial respiration.
[b/] Mass of methane produced during microbial respiration.

provide evidence of whether biodegradation is occurring, and the degree to which it is occurring.

Depending on the types and concentrations of electron acceptors present (e.g., nitrate, ferric iron, sulfate, carbon dioxide), pH conditions, and ORP, anaerobic biodegradation can occur by denitrification, ferric iron reduction, sulfate reduction, or methanogenesis. Other, less common anaerobic degradation mechanisms such as manganese or nitrate reduction may dominate if the physical and chemical conditions in the subsurface favor use of these electron acceptors. Anaerobic destruction of BTEX compounds is associated with the accumulation of fatty acids, production of methane, solubilization of iron, and reduction of nitrate and sulfate (Cozzarelli *et al.*, 1990; Wilson *et al.*, 1990). Environmental conditions and microbial competition will ultimately determine which processes will dominate. Vroblesky and Chapelle (1994) show that the dominant terminal electron accepting process can vary both temporally and spatially in an aquifer with fuel hydrocarbon contamination.

Site groundwater data for electron acceptors at Zone 1 indicate that natural attenuation of hydrocarbons in the shallow aquifer may be occurring by aerobic oxidation, ferric iron reduction, denitrification, sulfate reduction, and methanogenesis. This is evidenced by significant changes in groundwater geochemistry in comparison to background conditions, as shown in the following subsections. Areas of Zone 1 that show the greatest variation in concentrations of geochemical parameters generally correspond well with areas of low redox potential and high BTEX concentrations. Table 4.5 summarizes groundwater geochemical data gathered during the RNA site investigation at Westover ARB. Geochemical parameters for Zone 1 are discussed in the following sections.

As a result of differing contaminant and geochemical conditions, it was concluded that data from IW-3 at site WP-15 were not representative of Zone 1. Unlike the rest of Zone 1, the concentrations of CAH compounds at this well are much higher than the

TABLE 4.5
GROUNDWATER GEOCHEMICAL ANALYTICAL DATA
ZONE 1
REMEDIATION BY NATURAL ATTENUATION
WESTOVER ARB, MASSACHUSETTS

Sample ID	Date Sampled	Temperature (°C)	pH	Conductivity (ms/cm)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L)	Total Redox Potential (mV)	Carbon Dioxide (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	NO_2^- (mg/L)	NO_3^- (mg/L)	Ferrous Iron (mg/L)	Mn^+ (mg/L)	NH_3^+ (mg/L)	Methane (mg/L)	TOC (mg/L)
CEA-2	9/10/96	15.7	5.83	170	0.51	85	-120	80	11.7	6.8	<0.076	0.12	8.0	0.1	2	0.65	NA[a/]
CEA-4	9/12/96	16.4	5.71	190	0.84	45	-170.5	50	25.1	14.5	<0.076	2.4	4.5	0.3	0.4	0.147	NA
CEA-5	9/11/96	15.3	5.92	1730	0.87	70	-151.7	80	18.4	5.4	<0.076	1.1	11.6	0.2	1.5	0.017	NA
ECS-20	9/14/96	17.9	6.46	NA	1.7	80	-66.4	50	50	3.4	<0.076	0.71	13.5	0.3	4	2.2	NA
ECS-22	9/14/96	16.4	6.11	NA	2.94	45	36	30	18.2	10.5	NA	3.1	0.08	ND[b/]	<0.1	ND	NA
ECS-23	9/13/96	15.4	6.39	NA	1.52	125	48.3	30	5.7	11.3	<0.076	0.18	0.05	0.1	<0.1	ND	NA
ECS-24	9/11/96	15.4	5.54	70	0.83	25	-130	55	4.2	10.3	<0.076	1.1	4.6	0.3	0.8	0.011	NA
ECS-26	9/12/96	14.7	5.70	230	0.44	140	-111.1	260	7.5	11.3	0.076	0.57	19.1	0.4	7	ND	NA
ECS-27	9/12/96	13.8	6.00	50	9.51	15	114.2	14	4.2	10.9	<0.076	1.2	ND	ND	<0.1	ND	1.7
ECS-28	9/13/96	14.2	5.97	NA	0.68	100	-66.7	102	3.1	7.5	<0.076	0.16	16.85	0.6	9	2.2	NA
ECS-29	9/12/96	14.0	5.63	NA	2.58	45	101	50	3	17	<0.076	2.8	2.12	0.1	<0.1	0.01	NA
ECS-30	9/11/96	14.5	5.70	80	0.72	45	83	55	4	4.3	<0.076	0.62	5.8	0.4	1	0.022	NA
ECS-31	9/10/96	14.5	5.59	100	1.59	70	39	50	3.7	2.7	<0.076	0.18	10	2.4	1	ND	2.7
IW-3	9/13/96	17.2	5.42	NA	0.55	1200	-157.6	700	6	0.8	<0.076	0.064	288	10.6	>10	8.5	NA
MP-1	9/12/96	13.2	6.06	NA	1.33	65	31	70	3.6	9.2	<0.076	0.41	2.82	1.3	<0.1	0.009	NA
MP-2	9/13/96	14.9	5.83	NA	3.11	55	-9.3	35	4.4	5.6	<0.076	3.5	0.43	0.4	0.1	0.005	NA
MP-3	9/12/96	13.3	5.63	70	0.64	45	0.2	60	3.1	4.5	<0.076	0.29	8.9	1.2	1	ND	NA
MP-4	9/12/96	13.1	5.56	40	9.8	10	77.2	<10	3.4	5.9	<0.076	1.4	0.02	ND	<0.1	ND	NA
MP-5D	9/12/96	15.8	5.89	130	0.6	65	-105.3	65	3.9	8.3	<0.076	<0.056	3.55	0.4	0.1	1.2	NA
MP-5S	9/12/96	16.9	5.95	70	9.95	15	6.6	17	3.8	8.9	<0.076	2.4	0.04	ND	0.1	ND	NA
MP-7	9/12/96	12.7	6.27	NA	0.82	40	73.9	35	2.8	15.1	<0.076	0.33	0.08	ND	<0.1	ND	NA
MP-8	9/12/96	14.7	6.10	220	0.88	115	-61.5	65	7	5.7	<0.076	<0.056	12.65	2.2	2	1.9	NA
MP-9	9/13/96	14.1	6.31	120	0.59	145	-109.7	100	4.9	1.3	<0.076	<0.056	13.95	1	>10	0.23	NA
MP-10	9/13/96	14.0	5.69	NA	7.3	40	169.4	32	0.9	36.8	NA	7	0.04	0.2	<0.1	ND	NA
MP-11D	9/15/96	16.9	5.65	NA	0.86	145	93.3	180	8	7.3	<0.076	<0.056	4.7	8.9	1.5	0.79	NA
MP-11S	9/15/96	13.9	5.32	NA	1.53	125	160.1	170	5.5	3.3	<0.076	0.14	10.8	0.9	1	1.69	NA
MP-12	9/15/96	17.9	5.91	NA	0.66	110	3.4	190	37.5	27.6	<0.076	<0.056	9.75	7.1	<1	0.143	NA
MP-13	9/15/96	16.5	6.02	NA	0.61	35	-122.9	27	31.2	34.7	<0.076	1.3	4.88	1	0.4	0.009	NA
MP-14D	9/15/96	18.8	6.37	NA	0.36	70	-207.5	70	12.5	12.8	<0.076	0.067	14.6	2.1	2	0.003	NA
MP-14S	9/15/96	15.8	5.83	NA	0.46	60	-106.0	110	12.2	4.8	<0.076	0.26	9.9	0.7	2.5	ND	NA
MW-2	9/14/96	13.6	5.59	NA	7.92	50	245.8	45	7.3	20.9	<0.076	9.5	0.01	ND	<0.1	ND	NA
MW-8	9/13/96	14.6	5.90	110	3.2	55	157.5	45	3.1	12.5	<0.076	1.3	0.95	0.2	<0.1	0.005	NA
MW-10	9/11/96	14.1	5.91	160	0.21	105	-36.5	150	5.2	1.8	<0.076	0.14	16.55	1.1	>10	0.005	NA
MW-11	9/11/96	15.6	5.23	80	0.6	NA	-105.5	70	5.8	6.1	<0.076	1.46	3.9	0.5	1.5	0.019	NA
MW-13	9/14/96	13.2	5.96	NA	5.83	40	313	35	9.1	12	<0.076	2.4	3.36	0.1	<0.1	0.016	NA

TABLE 4.5 (Concluded)
GROUNDWATER GEOCHEMICAL ANALYTICAL DATA
ZONE 1
REMEDIATION BY NATURAL ATTENUATION
WESTOVER ARB, MASSACHUSETTS

Sample ID	Date Sampled	Temperature (°C)	pH	Conductivity (ms/cm)	Dissolved Oxygen (mg/L)	Alkalinity (mg/L)	Total Redox Potential (mV)	Carbon Dioxide (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	NO_2^- (mg/L)	NO_3^- (mg/L)	Ferrous Iron (mg/L)	Mn^+ (mg/L)	NH_3^+ (mg/L)	Methane (mg/L)	TOC (mg/L)
MW-14	9/14/96	14.8	6.23	NA	2.17	75	-54.3	50	23.9	4.8	< 0.076	0.59	7.35	0.7	0.8	0.062	NA
MW-16	9/14/96	13.5	5.93	NA	4.88	85	272.4	50	6.7	16.5	< 0.076	1.6	0.02	0.4	< 0.1	0.6	NA
MW-17	9/13/96	14.1	6.22	NA	0.64	360	-192.5	250	5.1	2.6	< 0.076	0.14	48.7	4.0	10	4.6	174
MW-18	9/14/96	15.7	6.52	NA	0.34	260	109.9	180	9.3	2.3	< 0.076	0.12	24.3	3.4	> 10	4.1	NA
MW-19	9/14/96	28.3	6.01	NA	0.32	65	-70.5	70	17.1	9.1	0.8	2	3.25	3	1	0.75	NA
MW-36	9/10/96	14.7	4.69	40	10.75	10	104	< 10	2.6	5.7	< 0.076	2.2	0.02	0.1	0.1	ND	NA
MW-37	9/11/96	13.2	5.24	50	6.42	10	108	< 10	3.1	4.5	< 0.076	3.8	ND	0.1	0.1	ND	NA
MW-38	9/10/96	15.2	5.61	80	8.96	20	142	NA	7.6	12.3	< 0.076	3.5	0.01	0.1	0.1	0.003	1.7
MW-39	9/11/96	13.1	5.38	50	4.74	25	118	19	3.6	6.9	< 0.076	0.88	0.01	ND	0.1	ND	NA
OBG-7	9/14/96	16.9	5.88	NA	2.9	25	27	26	37.7	4.5	NA	1.6	2.15	ND	0.1	0.004	NA
OBG-8	9/15/96	16.1	6.28	NA	0.61	50	-72.5	45	57.6	4.7	< 0.076	0.52	9.6	0.3	2	0.007	NA
OBG-10	9/15/96	15.3	5.92	NA	1.00	35	-37.2	35	40	10.9	< 0.076	2.5	1.82	0.2	< 0.1	0.004	NA
OBG-11	9/14/96	14.2	6.36	NA	3.34	30	93.9	19	32	8.6	< 0.076	2.2	0.02	ND	< 0.1	ND	NA
OBG-41	9/10/96	18.5	5.41	210	1.61	25	125.7	30	40.6	14.3	< 0.076	4	0.01	ND	0.1	ND	NA

a/ NA = Not analyzed.
b/ ND = Not detected.

concentration of dissolved BTEX compounds. Furthermore, geochemical conditions at IW-3 are much more methanogenic than the rest of Zone 1. These two conditions contribute to biodegradation pathways dissimilar to the other portions of Zone 1. Because groundwater in the general area of WP-15 exhibits such different characteristics from the rest of Zone 1 and BTEX concentrations are relatively low, this area is not included in the following subsections on fuel hydrocarbon degradation. However, WP-15 is discussed in Section 4.3.4, along with chlorinated solvent degradation pathways.

In the following sections, the assumption that BTEX can be treated through RNA as a given ratio of the constituent compounds has been made for two important reasons. First, biodegradation rates of each of the compounds are very similar to each other. Second, while degradation pathways are relatively well known for fuel hydrocarbons, the preferential degradation of one BTEX compound over another is difficult to predict from site to site, spatially or temporally. In order to avoid drawing inaccurate conclusions on the spatial and temporal degradation of individual BTEX compounds, the compounds are treated as a ratio. This ratio provides a basis for more reliable conclusions about the spatial and temporal biodegradation of BTEX as one contaminant.

4.3.2.1 Dissolved Oxygen

DO concentrations were measured at monitoring wells at the time of groundwater sampling in September 1996. Table 4.5 summarizes measured DO concentrations. Figure 4.2 presents an isopleth map showing the distribution of DO concentrations in shallow groundwater. These data provide strong evidence that aerobic biodegradation of the BTEX compounds is occurring in groundwater at Zone 1. Given high background DO concentrations in the shallow groundwater (9.0 mg/L at monitoring well MW-38) and negligible DO concentrations within the areas observed to have dissolved fuel hydrocarbon contamination, it is likely that DO is an important electron

acceptor throughout Zone 1. Within the areas characterized by substantially elevated dissolved BTEX concentrations (greater than 100 μg/L), DO was less than 1 mg/L.

The stoichiometry of BTEX mineralization to carbon dioxide and water caused by aerobic microbial biodegradation is presented in Table 4.4. The average mass ratio of oxygen to total BTEX is approximately 3.14 to 1. This translates to the mineralization of approximately 0.32 mg of BTEX for every 1.0 mg of DO consumed. With an assumed background DO concentration of 9.0 mg/L, the shallow groundwater has the capacity to assimilate 2.88 mg/L (2,880 μg/L) of total BTEX through aerobic biodegradation. This may be a conservative estimate of the assimilative capacity of DO because microbial cell mass production was not taken into account by the stoichiometry present in Table 4.4.

When cell mass production is accounted for, the mineralization of benzene to carbon dioxide and water is given by:

$$C_6H_6 + 2.5O_2 + HCO_3 + NH_4 \rightarrow C_5H_7O_2N + 2CO_2 + 2H_2O$$

From this it can be seen that 5 fewer moles of DO are required to mineralize 1 mole of benzene when cell mass production is taken into account. On a mass basis, the ratio of DO to benzene is given by:

Benzene $6(12) + 6(1) = 78$ gm

Oxygen $2.5(32) = 80$ gm

Mass Ratio of Oxygen to Benzene = $80/78 = 1.03:1$

On the basis of these stoichiometric relationships, 1.03 mg of oxygen is required to mineralize 1 mg of benzene, if cell mass is being produced. Similar calculations can be made for toluene, ethylbenzene, and the xylenes. On the basis of these calculations,

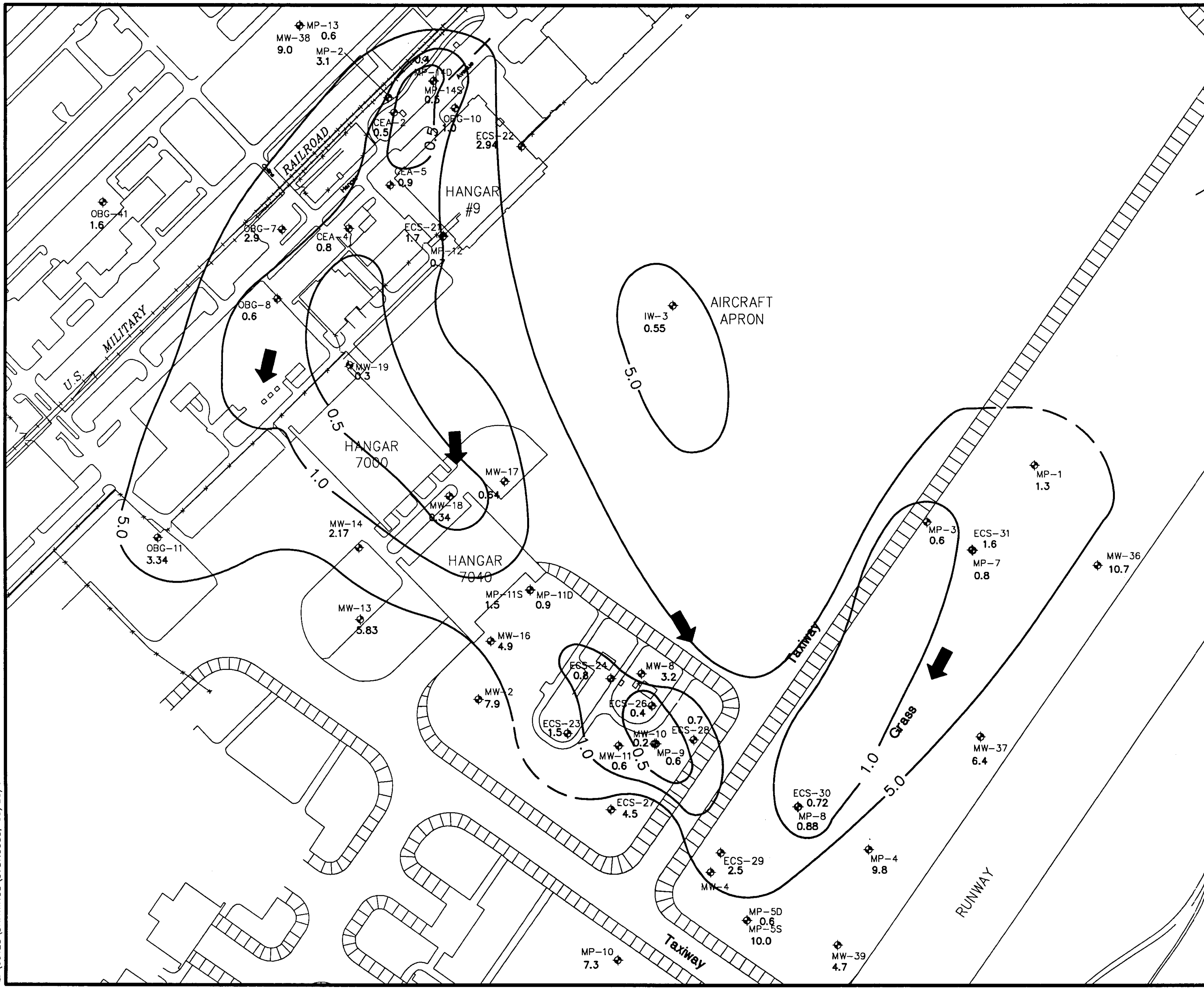
approximately 0.95 mg of BTEX is mineralized to carbon dioxide and water for every 1.0 mg of DO consumed.

Although this process results in more efficient utilization of electron acceptors, it is only applicable as the net cell mass of the microbial population continues to grow. Because groundwater contamination has been present at Zone 1 for several years, it is possible that biomass mass production has reached steady-state. In this case, the cell mass reaction equations would no longer apply.

4.3.2.2 Nitrate/Nitrite

Concentrations of nitrate and nitrite [as nitrogen (N)] were measured in groundwater samples collected in September 1996. Table 4.5 summarizes measured nitrate/nitrite (as N) concentrations. Nitrite was not detected above the method detection limit at any of the sampling locations except monitoring well MW-19. Figure 4.3 presents an isopleth map depicting nitrate distribution in groundwater. The data from Zone 1 indicate reduced nitrate concentrations throughout the groundwater BTEX plume, suggesting that nitrate is an important electron acceptor. Nitrate was detected in site groundwater at concentrations ranging from <0.05 mg/L to 9.5 mg/L.

In the absence of microbial cell production, the stoichiometry of BTEX mineralization to carbon dioxide, water, and nitrogen caused by denitrification is presented in Table 4.4. The average mass ratio of nitrate to total BTEX is approximately 4.9 to 1. This translates into the mineralization of approximately 0.20 mg of BTEX for every 1.0 mg of nitrate consumed. Due to the variation of nitrate levels between the BTEX plume boundaries and the background wells, a background nitrate concentration of 3.5 mg/L as N was assumed for September 1996. Because the nitrate concentrations are reported as mg/L as N, the measured concentrations must be multiplied by 4.42 to be converted to mg/L as NO_3^-. Therefore, the shallow groundwater at this site has the capacity to assimilate 3.1 mg/L (3,100 µg/L) of total



LEGEND

MP-1 1.33 — MONITORING LOCATION WITH DISSOLVED OXYGEN CONCENTRATION (mg/L)

1.0 — LINE OF EQUAL DISSOLVED OXYGEN CONCENTRATION (mg/L) (DASHED WHERE INFERRED)

APPROXIMATE GROUNDWATER FLOW DIRECTION

NOTE:
WHERE MULTIPLE SAMPLES WERE COLLECTED AT THE SAME LOCATION, THE CONCENTRATION FROM THE SHALLOWER MONITORING WELL/POINT WAS USED FOR ISOPLETH CONSTRUCTION.

N

0 150 300
FEET

FIGURE 4.2

DISSOLVED OXYGEN ISOPLETH MAP SEPTEMBER 1996

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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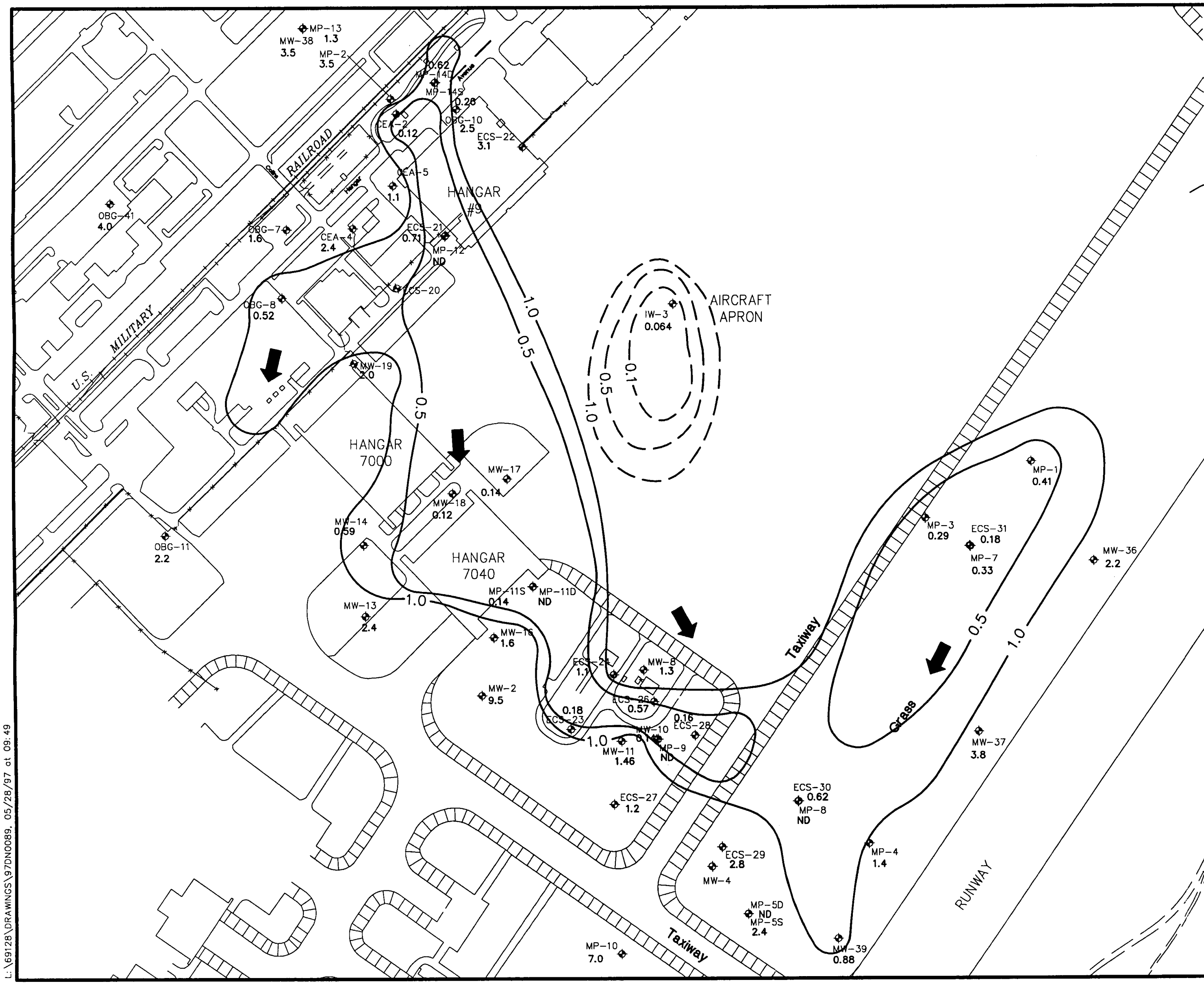
BTEX during nitrate reduction. Because biomass accumulation is not considered, the actual assimilative capacity attributable to nitrate reduction could be somewhat higher.

4.3.2.3 Ferrous Iron

Fe^2 concentrations were measured in groundwater samples collected in September 1996. Table 4.5 summarizes ferrous iron concentrations, and Figure 4.4 presents an isopleth map showing the distribution of ferrous iron in groundwater. Comparison of Figures 4.1, 4.2, and 4.4 indicates that ferrous iron is being produced in the anaerobic portion of the BTEX plume due to the reduction of ferric iron hydroxide (Fe^{3+}) during anaerobic biodegradation of BTEX compounds. Background ferrous iron concentrations are as low as <0.01 mg/L, as measured at wells with little or no BTEX concentration. Groundwater from monitoring well IW-3, at site WP-15, had the highest ferrous iron concentrations, with 288 mg/L of Fe^{2+}. However, at sites SS-19 and SS-16, the highest concentrations of ferrous iron were detected at levels significantly below 100 mg/L. Elevated ferrous iron concentrations are a strong indication that anaerobic biodegradation of BTEX compounds is occurring in the shallow groundwater through iron reduction.

The stoichiometry of BTEX oxidation to carbon dioxide, ferrous iron, and water by microbial iron reduction is presented in Table 4.4. On average 37.5 moles of ferric iron hydroxide are required to metabolize 1 mole of total BTEX. Conversely, an average of 37.5 moles of ferrous iron are produced for each mole of total BTEX consumed. On a mass basis, this translates to approximately 21.8 mg ferrous iron produced for each mg of total BTEX metabolized. Given a background ferrous iron concentration of 0.01 mg/L and using a conservative 40 mg/L for the plume interior (the average of elevated ferrous iron concentrations observed at SS-19 and SS-16), the groundwater at Zone 1 has the capacity to assimilate 1.83 mg/L (1,830 μg/L) of total BTEX through iron reduction. This is a conservative estimate of the assimilative capacity of iron because the calculation is based on observed ferrous iron



LEGEND

MP-1 0.41 — MONITORING LOCATION WITH GROUNDWATER NITRATE CONCENTRATION (mg/L)

1.0 — LINE OF EQUAL GROUNDWATER NITRATE CONCENTRATION (mg/L) (DASHED WHERE INFERRED)

APPROXIMATE GROUNDWATER FLOW DIRECTION

ND — NOT DETECTED

NOTE:
WHERE MULTIPLE SAMPLES WERE COLLECTED AT THE SAME LOCATION, THE CONCENTRATION FROM THE SHALLOWER MONITORING WELL/POINT WAS USED FOR ISOPLETH CONSTRUCTION.

FIGURE 4.3

NITRATE (as N) ISOPLETH MAP SEPTEMBER 1996

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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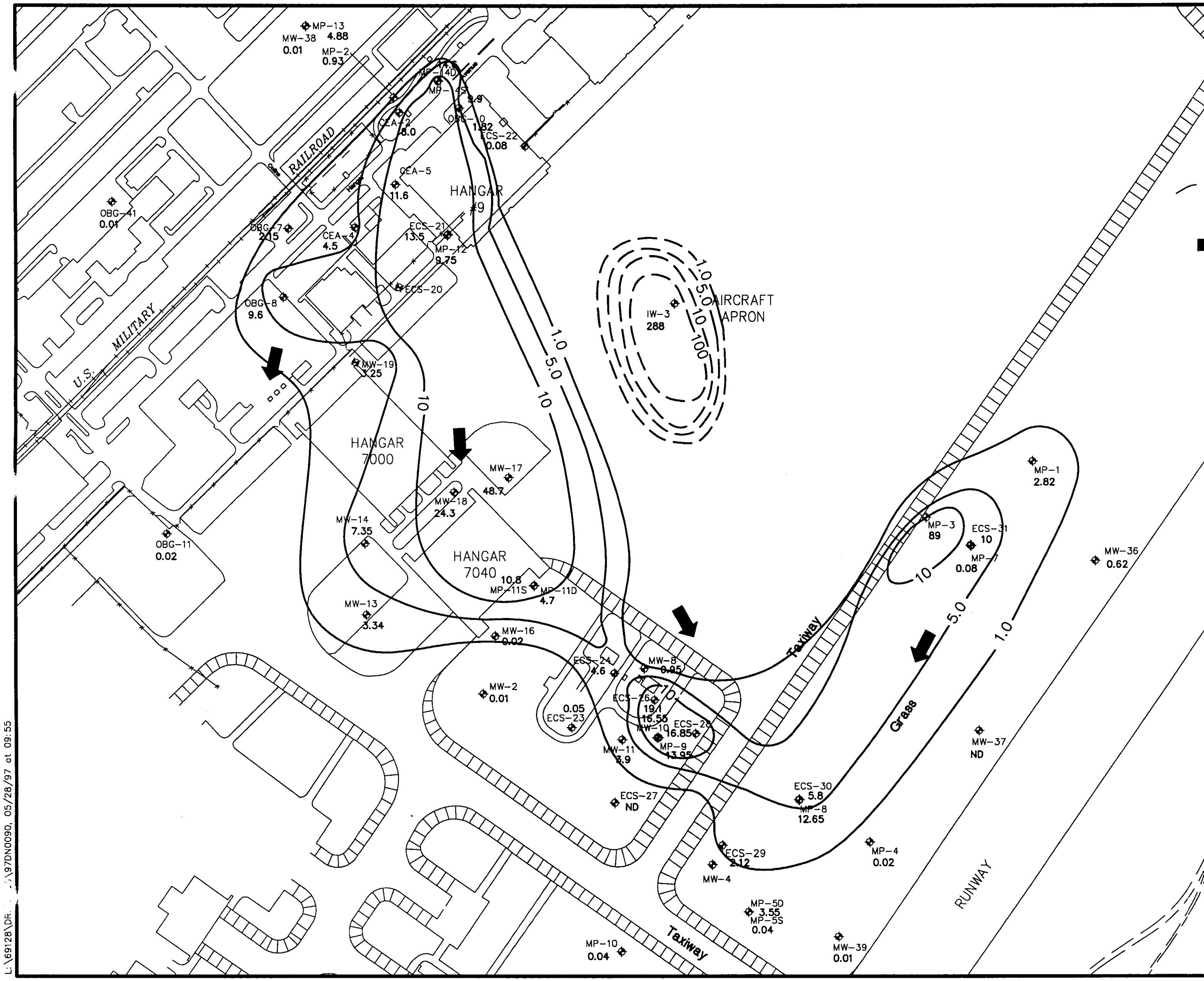

LEGEND

MP-1 2.82 — MONITORING LOCATION WITH DISSOLVED FERROUS IRON CONCENTRATION (mg/L)

1.0 — LINE OF EQUAL DISSOLVED FERROUS IRON CONCENTRATION (mg/L) (DASHED WHERE INFERRED)

APPROXIMATE GROUNDWATER FLOW DIRECTION

NOTE:
WHERE MULTIPLE SAMPLES WERE COLLECTED AT THE SAME LOCATION, THE CONCENTRATION FROM THE SHALLOWER MONITORING WELL/POINT WAS USED FOR ISOPLETH CONSTRUCTION.

FIGURE 4.4

FERROUS IRON ISOPLETH MAP SEPTEMBER 1996

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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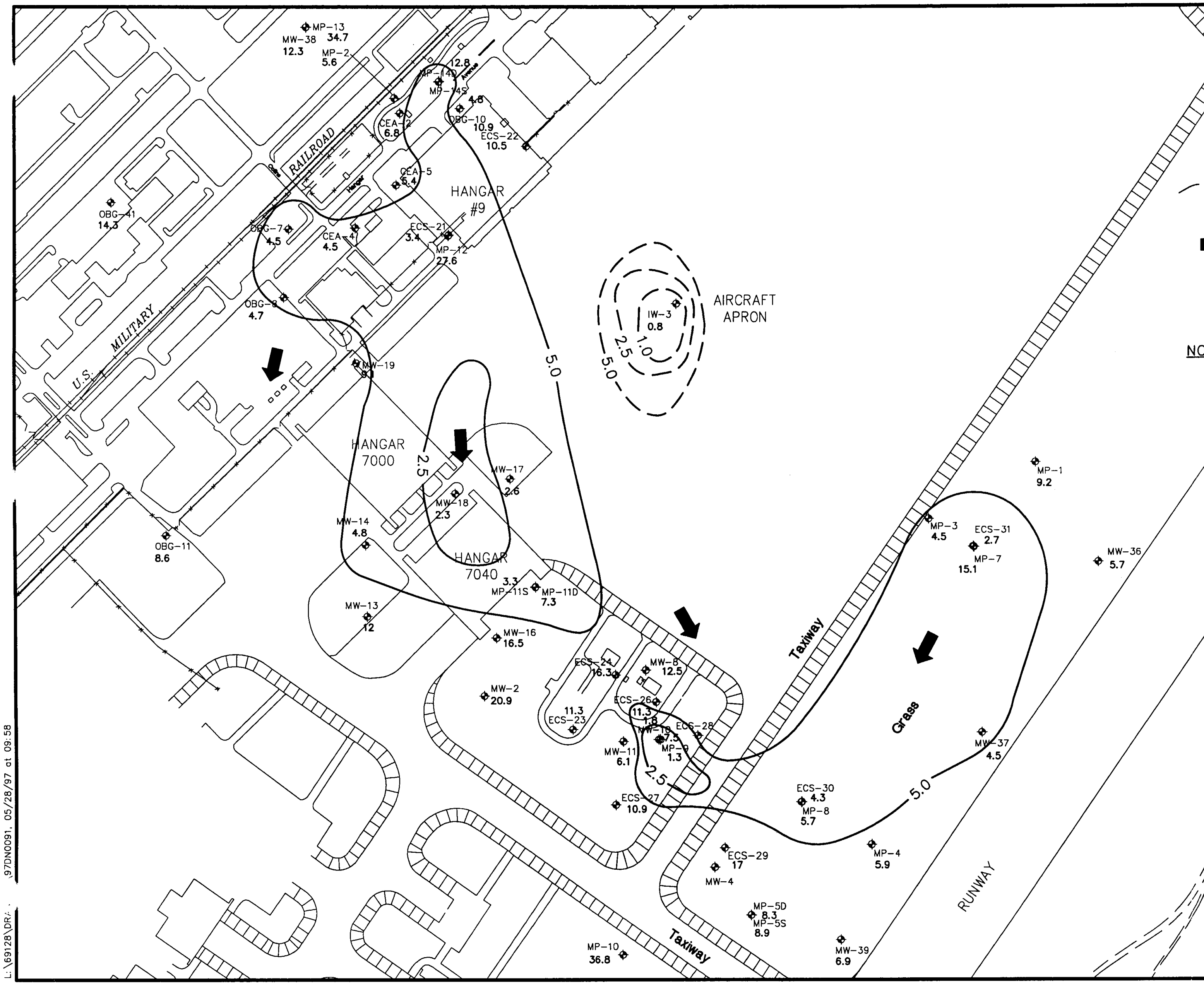
concentrations and not on the amount of ferric hydroxide available in the aquifer. Therefore, iron assimilative capacity could be much higher.

Recent evidence suggests that the reduction of ferric iron to ferrous iron cannot proceed at all without microbial mediation (Lovley and Phillips, 1988; Lovley *et al.*, 1991; Chapelle, 1993). None of the common organic compounds found in low-temperature, neutral, reducing groundwater could reduce ferric oxyhydroxides to ferrous iron under sterile laboratory conditions (Lovley *et al.*, 1991). This means that the reduction of ferric iron requires microbial mediation by microorganisms with the appropriate enzymatic capabilities. Because the reduction of ferric iron cannot proceed without microbial intervention, the elevated concentrations of ferrous iron that were measured in the contaminated groundwater at the site are very strong indicators of microbial activity.

4.3.2.4 Sulfate

Sulfate concentrations were measured in groundwater samples collected in September 1996. Sulfate concentrations at the site ranged from 1.3 mg/L to 36.8 mg/L. Table 4.5 summarizes measured sulfate concentrations. Figure 4.5 presents an isopleth map illustrating the areal extent of sulfate in groundwater for the September 1996 sampling event. Comparison of Figures 4.1, 4.2, and 4.5 shows graphically that the area of depleted sulfate concentrations corresponds to the anaerobic portions of the BTEX plume. This is a strong indication that anaerobic biodegradation of the BTEX compounds is occurring at the site via sulfate reduction.

The stoichiometry of BTEX mineralization to carbon dioxide, sulfur, and water by microbial sulfate reduction is presented in Table 4.4. The average mass ratio of sulfate to total BTEX is approximately 4.7 to 1. This translates to the mineralization of approximately 0.21 mg of total BTEX for every 1.0 mg of sulfate consumed. Assuming an average background sulfate concentration of 13.0 mg/L and a minimum sulfate concentration of 1.3 mg/L, the shallow groundwater at this site has the capacity



LEGEND

MP-1 9.2 — MONITORING LOCATION WITH GROUNDWATER SULFATE CONCENTRATION (mg/L)

1.0 — LINE OF EQUAL GROUNDWATER SULFATE CONCENTRATION (mg/L) (DASHED WHERE INFERRED)

APPROXIMATE GROUNDWATER FLOW DIRECTION

ND — NOT DETECTED

NOTE:
WHERE MULTIPLE SAMPLES WERE COLLECTED AT THE SAME LOCATION, THE CONCENTRATION FROM THE SHALLOWER MONITORING WELL/POINT WAS USED FOR ISOPLETH CONSTRUCTION.

0 150 300
FEET

FIGURE 4.5

SULFATE ISOPLETH MAP SEPTEMBER 1996

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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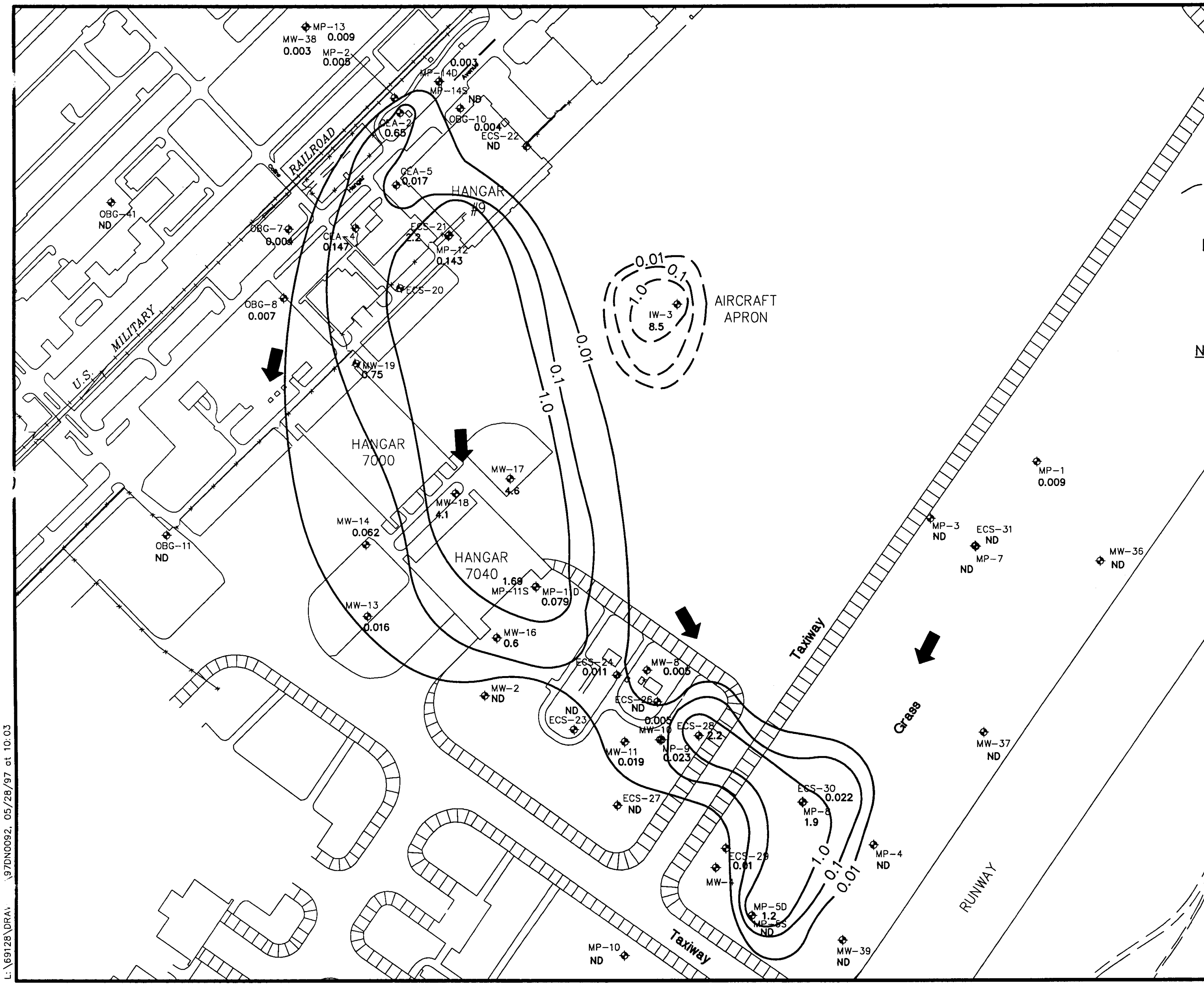
to assimilate 2.46 mg/L (2,460 μg/L) of total BTEX through sulfate reduction. Because biomass accumulation is not considered, the actual assimilative capacity attributable to sulfate reduction could be somewhat higher.

4.3.2.5 Methane

Methane concentrations were measured in groundwater samples collected in September 1996. Table 4.5 summarizes methane concentrations, which ranged from below 0.001 mg/L to 2.2 mg/L, not including the samples taken from the area included in site WP-15. Figure 4.6 presents an isopleth map showing the distribution of methane in groundwater for Zone 1. Comparison of Figures 4.1 and 4.6 illustrates that the areas with elevated total BTEX concentrations correlate with elevated methane concentrations. Outside of the BTEX plume, the methane concentrations are <0.001 mg/L (the analytical quantitation limit). At sites SS-19 and SS-16 the highest methane concentration of 2.2 mg/L was measured at monitoring well ECS-21.

The stoichiometry of BTEX oxidation to carbon dioxide and methane by methanogenesis is presented in Table 4.4. On average, approximately 1 mg of total BTEX is mineralized for every 0.78 mg of methane produced. Given a maximum detected methane concentration of 2.2 mg/L in September 1996, the shallow groundwater exhibits the capacity to assimilate approximately 2.82 mg/L (2,820 μg/L) of total BTEX through methanogenesis. This is a conservative estimate of the assimilative capacity of methanogenesis because calculations are based on observed methane concentrations and not on the amount of carbon dioxide (the electron acceptor for methanogenesis) available in the aquifer. Because methanogenesis produces more carbon dioxide than it consumes, an unlimited supply of carbon dioxide is theoretically available once the process of methanogenesis has been initiated. Therefore, methanogenesis is limited by the rate of reaction rather than the source of electron acceptors.



LEGEND

MP-1 0.009 — MONITORING LOCATION WITH GROUNDWATER METHANE CONCENTRATION (mg/L)

1.0 — LINE OF EQUAL GROUNDWATER METHANE CONCENTRATION (mg/L) (DASHED WHERE INFERRED)

APPROXIMATE GROUNDWATER FLOW DIRECTION

ND — NOT DETECTED

NOTE:

WHERE MULTIPLE SAMPLES WERE COLLECTED AT THE SAME LOCATION, THE CONCENTRATION FROM THE SHALLOWER AQUIFER MONITORING WELL/POINT WAS USED FOR ISOPLETH CONSTRUCTION.

N

0 150 300

FEET

FIGURE 4.6

METHANE ISOPLETH MAP SEPTEMBER 1996

Zone 1

Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

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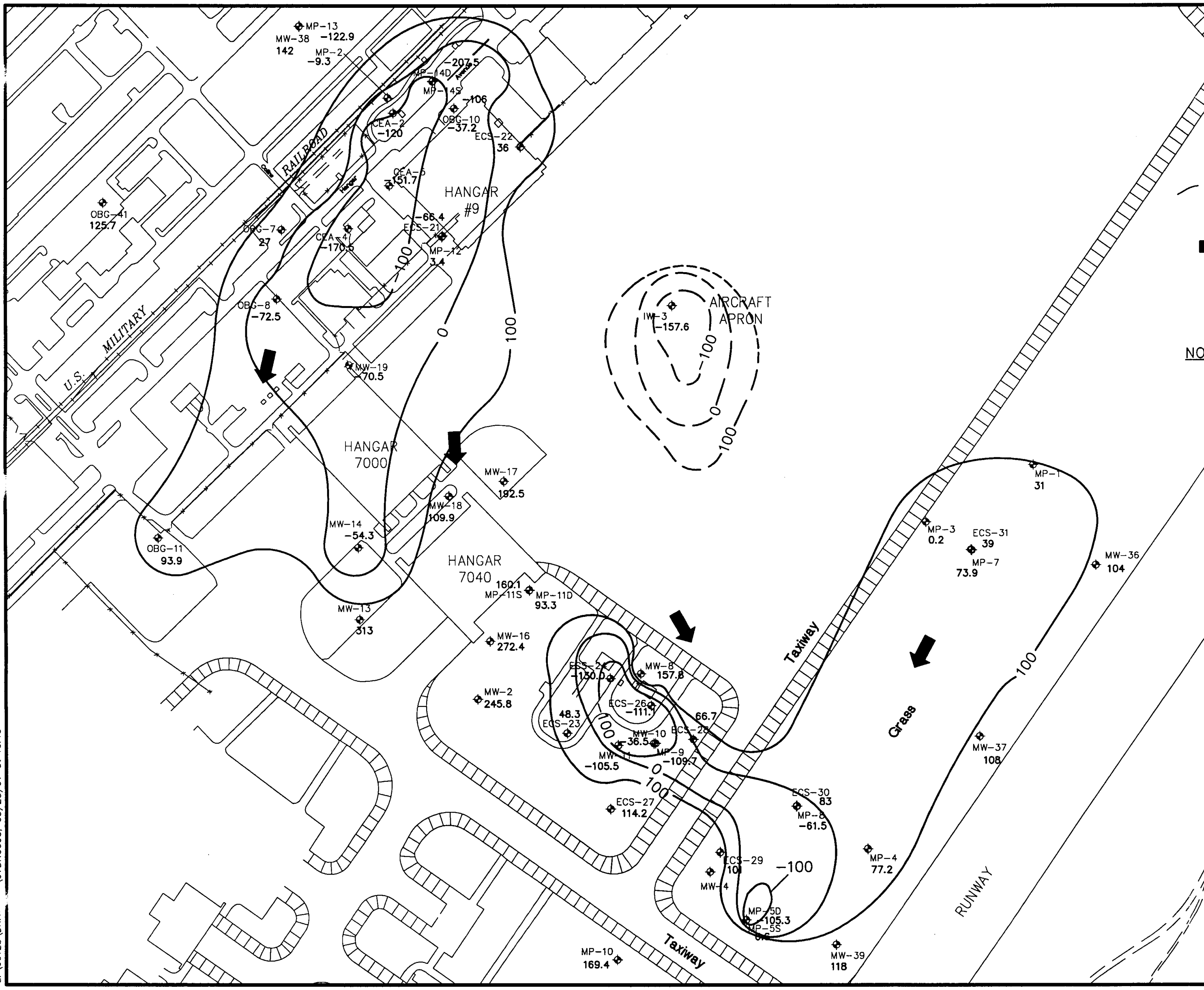
4.3.2.6 Reduction/Oxidation Potential

ORP is a measure of the relative tendency of a solution to accept or transfer electrons. The ORP of a groundwater system depends on which electron acceptors are being reduced by microbes during BTEX oxidation. ORPs were measured at groundwater monitoring wells in September 1996. These measurements are summarized in Table 4.5. ORPs at the site ranged from -207 millivolts (mV) to 313 mV. Figure 4.7 presents the areal extent of reduced ORPs. As expected, areas at the site with low ORPs coincide with areas of high BTEX contamination, low DO, nitrate, and sulfate concentrations, and elevated ferrous iron and methane concentrations.

The ORPs measured at the site may be higher than the theoretical optimum ORPs for various electron acceptor reactions (Norris *et al.*, 1994). This discrepancy is a common problem associated with measuring oxidizing potential using field instruments. It is likely that the platinum electrode probes are not sensitive to some of the redox couples (e.g., sulfate/sulfide). Many authors have noted that field measured ORP data alone cannot be used to reliably predict the electron acceptors that may be operating at a site (Stumm and Morgan, 1981; Godsey, 1994; Lovley *et al.*, 1994). Integrating ORP measurements with analytical data on reduced and oxidized chemical species allows a more thorough and reasonable interpretation of which electron acceptors are being used to biodegrade site contaminants.

4.3.2.7 Alkalinity

Alkalinity is a measure of the ability of groundwater to buffer changes in pH caused by the addition of biologically generated acids. In September 1996, total alkalinity (as calcium carbonate) was measured in groundwater samples. These measurements are summarized in Table 4.5. Figure 4.8 presents and isopleth map depicting areas of elevated alkalinity. Total alkalinity at the site ranges from 10 mg/L to 145 mg/L. The total background alkalinity, 20 mg/L at MW-38, at Zone 1 is in the low range for groundwater. The increase in alkalinity in the areas of groundwater BTEX



LEGEND

MP-1 73.9 — MONITORING LOCATION WITH GROUNDWATER REDOX POTENTIAL (mV)

0 — LINE OF EQUAL GROUNDWATER REDOX POTENTIAL (mV) (DASHED WHERE INFERRED)

APPROXIMATE GROUNDWATER FLOW DIRECTION

NOTE:
WHERE MULTIPLE SAMPLES WERE COLLECTED AT THE SAME LOCATION, THE MINIMUM POTENTIAL WAS USED FOR ISOPLETH CONSTRUCTION.

N

0 150 300
FEET

FIGURE 4.7

GROUNDWATER REDOX POTENTIAL ISOPLETH MAP SEPTEMBER 1996

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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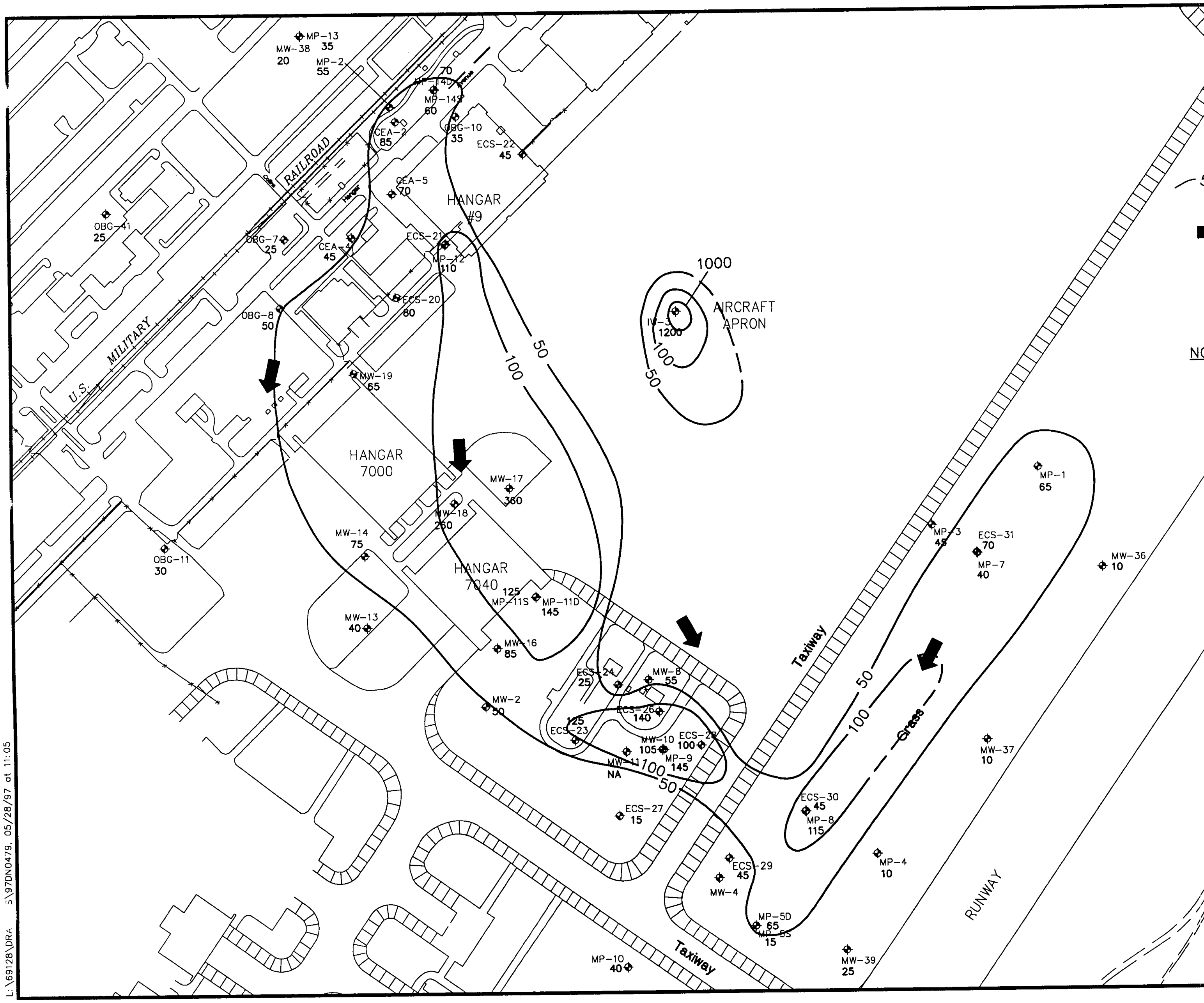

LEGEND

MP-1 65 — MONITORING LOCATION WITH AKLALINITY (mg/L)

50 — LINE OF EQUAL ALKALINITY (mg/L) (DASHED WHERE INFERRED)

APPROXIMATE GROUNDWATER FLOW DIRECTION

NOTE:
WHERE MULTIPLE SAMPLES WERE COLLECTED AT THE SAME LOCATION, THE MAXIMUM CONCENTRATION WAS USED FOR ISOPLETH CONSTRUCTION.

FIGURE 4.8

ALKALINITY (as $CaCO_3$) ISOPLETH MAP SEPTEMBER 1996

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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contamination is in response to increased carbon dioxide levels that result from BTEX biodegradation. Increasing alkalinity acts as a buffer to the weakly acidic conditions brought about by an increase in carbon dioxide.

An increase in alkalinity in an area with BTEX concentrations elevated over background conditions can be used to infer the amount of petroleum hydrocarbon destroyed through aerobic respiration, denitrification, ferric iron reduction, and sulfate reduction. Methanogenesis does not cause significant changes in alkalinity in comparison to the other terminal-electron accepting processes. The molar ratio of alkalinity produced during benzene oxidation via aerobic respiration, denitrification, ferric iron reduction, and sulfate reduction is given by:

$$C_6H_6 \rightarrow 6CO_2 \rightarrow 6CaCO_3$$

Therefore, 6 moles of $CaCO_3$ are produced during the metabolism of 1 mole of benzene. A mass balance of this reaction demonstrates that for every 1 mg of alkalinity produced, 0.13 mg of benzene is destroyed. Similar calculations can be made for toluene, ethylbenzene, and xylene. Given an average background alkalinity of 20 mg/L and an average source area concentration of approximately 145 mg/L for both sampling events, as much as 16,250 μg/L of BTEX could have been destroyed by aerobic respiration, denitrification, ferric iron reduction, and sulfate reduction. This alone does not demonstrate natural attenuation; however, it does provide additional evidence that natural attenuation of fuel hydrocarbons is occurring within the groundwater BTEX plume.

4.3.2.8 Carbon Dioxide in Groundwater

Carbon dioxide is produced in the plume area as a byproduct of aerobic respiration, denitrification, iron reduction, sulfate reduction, and methanogenesis (Table 4.5). Groundwater carbon dioxide measurements were collected from site monitoring wells in September 1996. In September 1996, carbon dioxide concentrations ranged from 14 mg/L to 260 mg/L. Table 4.5 summarizes the groundwater carbon dioxide

measurements. Figure 4.9 presents an isopleth map of dissolved carbon dioxide at Zone 1. Comparison of the areas of elevated carbon dioxide with dissolved BTEX contamination (Figures 4.1 and 4.9) is further evidence that biodegradation of BTEX compounds is occurring.

4.3.2.9 pH

The pH of a solution is the negative logarithm of the hydrogen ion concentration $[H^+]$. pH was measured for groundwater samples collected from groundwater monitoring locations in September 1996. These measurements are summarized in Table 4.5. Groundwater pH measured at the site ranges from 4.69 to 6.52 standard units in September 1996. This range of pH is below optimal range for BTEX-degrading microbes; however, geochemical trends discussed in previous subsections suggests that BTEX degrading microbes are not being inhibited at Zone 1.

4.3.2.10 Temperature

Temperature affects the types and growth rates of bacteria that can be supported in the groundwater environment, with higher temperatures generally resulting in higher growth rates. Groundwater temperature measurements made in September 1996 are summarized in Table 4.5. Temperatures in the aquifer varied from 12.7 degrees Celsius (°C) to 18.8°C in 1996. These are relatively moderate temperatures for shallow groundwater, suggesting that bacterial growth rates should not be inhibited. An anomalous high temperature of 28.3°C was observed at MW-19. This well is located up against Hangar 7000 and water pumped from the well was noticeably warm compared to other sampling locations; however, no other anomalies were seen in geochemical parameters measured at MW-19.

4.3.2.11 Expressed Assimilative Capacity

The data presented in the preceding subsections suggest that mineralization of BTEX compounds is occurring through the microbially mediated processes of aerobic respiration, denitrification, iron reduction, sulfate reduction, and methanogenesis. On

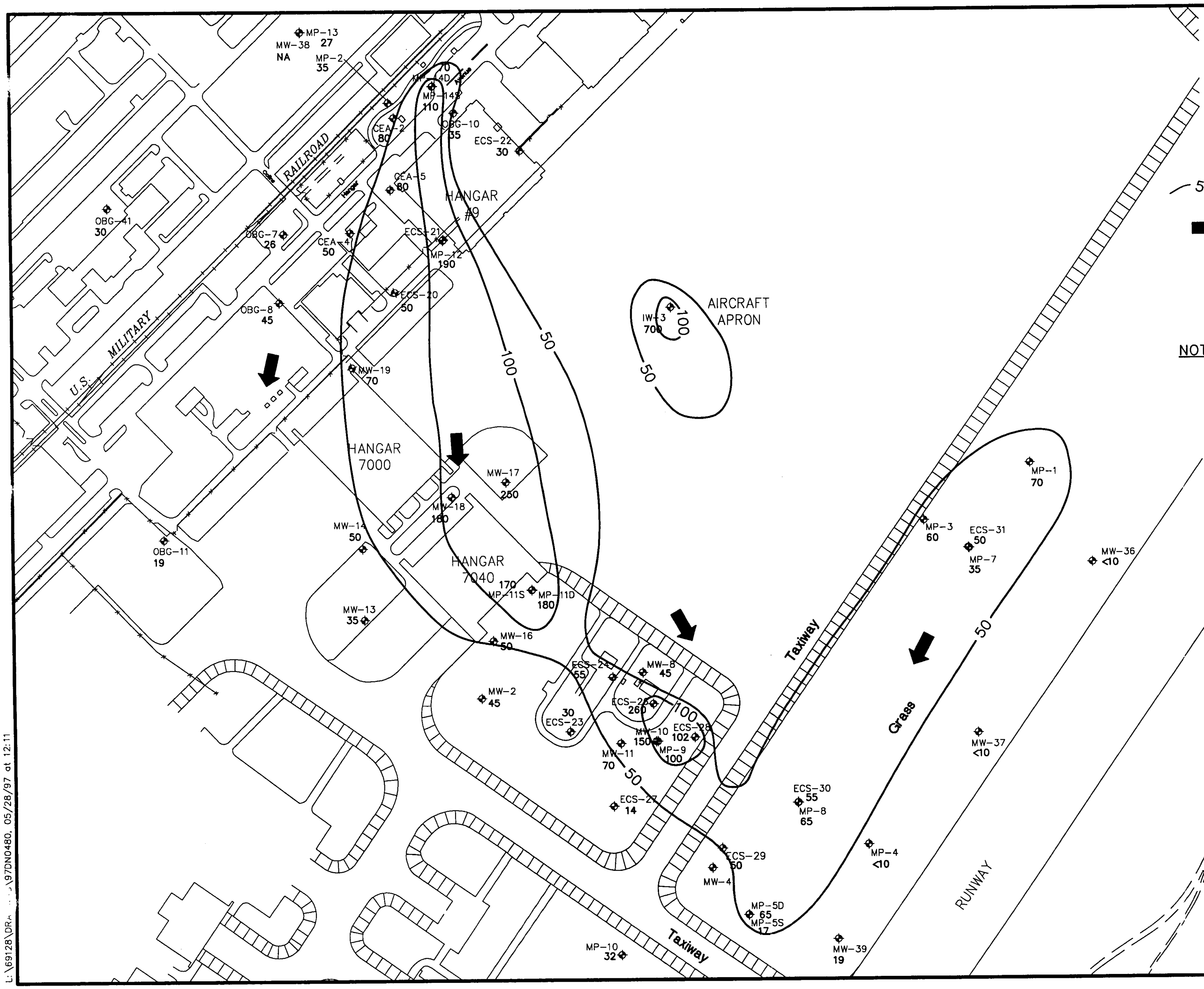

FIGURE 4.9

CARBON DIOXIDE IN GROUNDWATER ISOPLETH MAP SEPTEMBER 1996

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

the basis of the stoichiometry presented in Table 4.4, the expressed BTEX assimilative capacity of groundwater at Zone 1 for September 1996 is at least 13,090 μg/L (Table 4.6).

TABLE 4.6
EXPRESSED ASSIMILATIVE CAPACITY
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Natural Attenuation Mechanism	Assimilative Capacity September 1996 (µg/L)
Aerobic Respiration	2,880
Nitrate Reduction	3,100
Iron Reduction	1,830
Sulfate Reduction	2,460
Methanogenesis	2,820
Total Assimilative Capacity (µg/L)	13,090

A closed system containing 2 liters of water can be used to help visualize the physical meaning of assimilative capacity. Assume that the first liter contains no fuel hydrocarbons, but it contains fuel-degrading microorganisms and has an assimilative capacity of exactly "x" mg of fuel hydrocarbons. The second liter has no assimilative capacity; however, it contains fuel hydrocarbons. As long as these 2 liters of water are kept separate, the biodegradation of fuel hydrocarbons will not occur. If these 2 liters are combined in a closed system, biodegradation will commence and continue until the fuel hydrocarbons are depleted, the electron acceptors are depleted, or the environment becomes acutely toxic to the fuel-degrading microorganisms. Assuming a nonlethal environment, if less than "x" mg of fuel hydrocarbons are in the second liter, all of the fuel hydrocarbons will eventually degrade given a sufficient time; likewise, if greater

than "x" mg of fuel hydrocarbons were in the second liter of water, only "x" mg of fuel hydrocarbons would ultimately degrade.

The groundwater beneath a site is an open system, which continually receives additional electron acceptors from the flow of the aquifer and the percolation of precipitation. This means that the assimilative capacity is not fixed as it would be in a closed system, and therefore cannot be compared directly to contaminant concentrations in the groundwater. Rather, the expressed assimilative capacity of groundwater is intended to serve as a qualitative tool. The fate of BTEX in groundwater and the potential impact to receptors is dependent on the relationship between the kinetics of biodegradation and the solute transport velocity (Chapelle, 1994). This significant expressed assimilative capacity is a strong indicator that biodegradation is occurring; however, it is not a guarantee that biodegradation will proceed to completion before potential downgradient receptors are impacted.

The groundwater at Zone 1 appears to provide sufficient assimilative capacity to decrease the dissolved BTEX contaminant mass and limit plume migration over time. In addition, the calculations of assimilative capacity presented in the earlier sections are conservative because they do not account for microbial cell mass production, and the measured concentrations of ferrous iron and methane may not be the maximum achievable. There is also a potential for the influx of electron acceptors (particularly oxygen) through rainwater infiltration at the site. The addition of this water may further enhance the assimilative capacity of the site groundwater.

4.3.3 Degradation of Chlorinated Solvents

Chlorinated solvents can be transformed, directly or indirectly, by biological processes (e.g., Bouwer *et al.*, 1981; Wilson and Wilson, 1985; Miller and Guengerich, 1982; Nelson *et al.*, 1986; Bouwer and Wright, 1988; Little *et al.*, 1988; Mayer *et al.*, 1988; Arciero *et al.*, 1989; Cline and Delfino, 1989; Freedman and Gossett, 1989; Folsom *et al.*, 1990; Harker and Kim, 1990; Alvarez-Cohen and

McCarty, 1991a, 1991b; DeStefano *et al.*, 1991; Henry, 1991; McCarty *et al.*, 1992; Hartmans and de Bont, 1992; McCarty and Semprini, 1994; Vogel, 1994). Biodegradation of CAHs is similar in principle to biodegradation of BTEX as described in Section 4.3.2; however, CAH degradation typically results from a more complex series of processes. Whereas BTEX is biodegraded in essentially one step by acting as an electron donor/carbon source, CAHs may undergo several types of biodegradation involving several steps. CAHs may undergo biodegradation through three different pathways: use as an electron acceptor, use as an electron donor, or cometabolism, which is degradation resulting from exposure to a catalytic enzyme fortuitously produced during an unrelated process. At a given site, one or all of these processes may be operating, although at many sites the use of CAHs as electron acceptors appears to be the most expedient. A more complete description of the main types of biodegradation reactions affecting CAHs is presented in the following subsections.

4.3.3.1 Electron Acceptor Reactions (Reductive Dehalogenation)

Under anaerobic conditions, biodegradation of chlorinated solvents usually proceeds through a process called reductive dehalogenation. During this process, the halogenated hydrocarbon is used as an electron acceptor, not as a source of carbon, and a halogen atom is removed and replaced with a hydrogen atom. In general, reductive dehalogenation occurs by sequential dehalogenation from PCE to TCE to DCE to vinyl chloride to ethene as shown in Figure 4.10. Reductive dehalogenation of chlorinated solvent compounds is associated with the accumulation of daughter products and an increase in chloride. PCE, TCE, DCE, and vinyl chloride all have been detected at Zone 1. The presence of the daughter products, 1,2-DCE and vinyl chloride, and the high ratio of daughter products to source solvents (PCE and TCE) suggest that reductive dechlorination is active at Zone 1; however, chlorinated solvent concentrations detected at the site were too low to significantly change chloride concentrations from background as a result of reductive dechlorination. Analysis for ethene was not performed; however, the presence of highly reducing, methanogenic

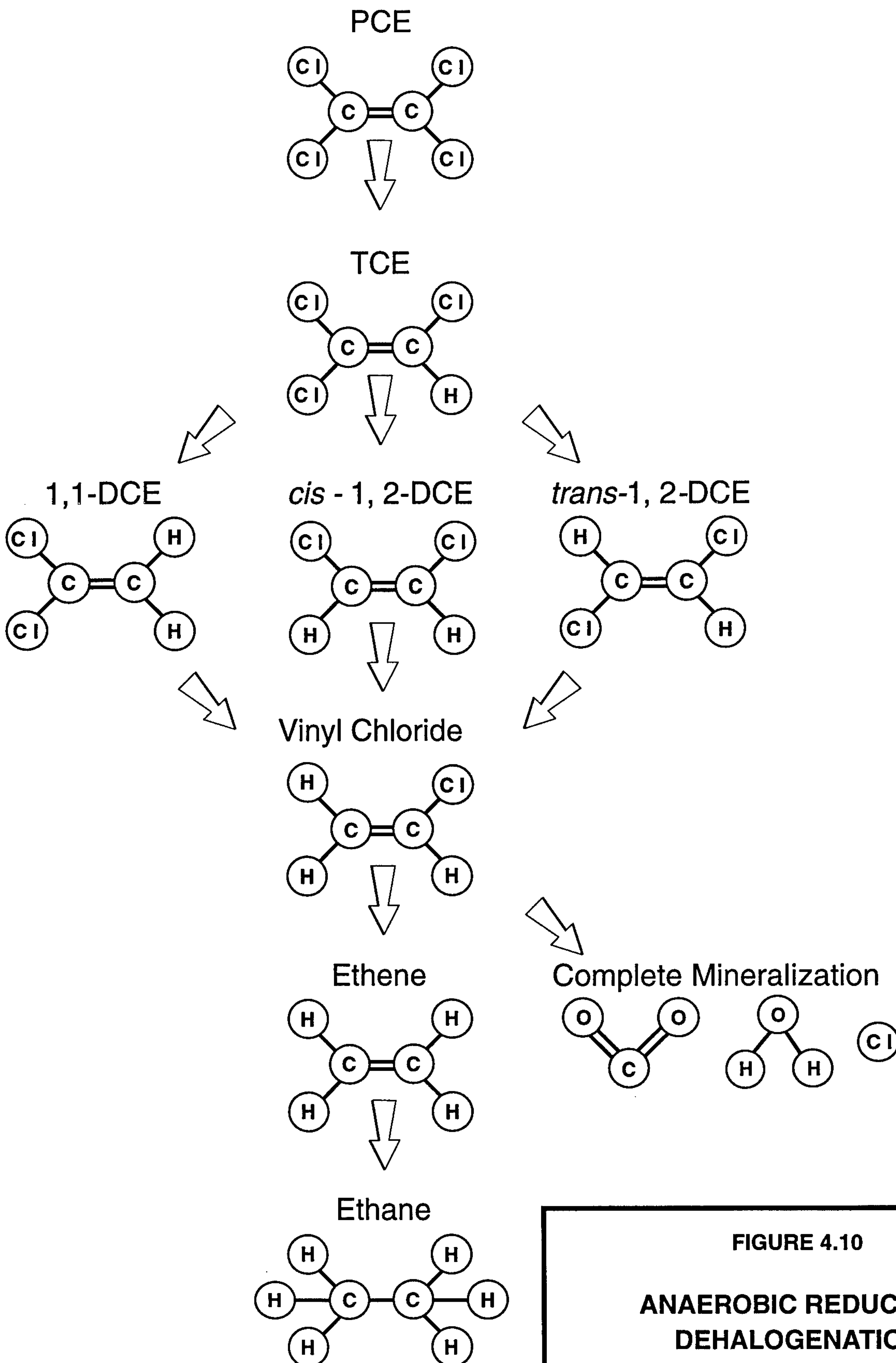

FIGURE 4.10

ANAEROBIC REDUCTIVE DEHALOGENATION

Zone 1
Remediation by Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

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conditions in the vicinity of monitoring well IW-3 suggests that vinyl chloride could be reductively dechlorinated to ethene within the WP-15 portion of Zone 1. Depending upon environmental conditions, the reductive dechlorination sequence may be interrupted, with other processes (e.g., electron donor reactions or cometabolism) then acting upon the products.

During reductive dehalogenation, all three isomers of DCE can theoretically be produced; however, Bouwer (1994) reports that under the influence of biodegradation, *cis*-1,2-DCE is a more common intermediate than *trans*-1,2-DCE, and that 1,1-DCE is the least prevalent intermediate of the three DCE isomers. At Zone 1, *cis*-1,2-DCE was the only DCE isomer detected with any confidence; *trans*-1,2-DCE was not detected; and 1,1-DCE was detected at estimated concentrations below 1μg/L, but also detected in laboratory blanks at comparable concentrations.

Reductive dehalogenation affects each of the chlorinated ethenes differently. Of these compounds, PCE is the most susceptible to reductive dehalogenation because it is the most oxidized. Conversely, vinyl chloride is the least susceptible to reductive dehalogenation because it is the least oxidized of these compounds. The rate of reductive dehalogenation also has been observed to decrease as the degree of chlorination decreases (Vogel and McCarty, 1985; Bouwer, 1994). Murray and Richardson (1993) have postulated that this rate decrease may explain the accumulation of vinyl chloride in TCE plumes that are undergoing reductive dehalogenation. Under many geochemical conditions, an accumulation of *cis*-1,2-DCE also can be observed prior to dechlorination to vinyl chloride or degradation through other mechanisms. Such is the case at Zone 1. Because vinyl chloride is not observed frequently or at high levels at the WP-15 site in Zone 1, it is likely that the reductive dehalogenation of *cis*-1,2-DCE to vinyl chloride is occurring at a very low rate and only in the core of the dissolved chlorinated plume, where conditions are likely to be the most reducing and the availability of electron donors is the highest.

In addition to being affected by the degree of chlorination of the CAH, reductive dehalogenation can also be controlled by the redox conditions of the site groundwater system. In general, reductive dehalogenation has been demonstrated under anaerobic nitrate- and sulfate-reducing conditions, but the most rapid biodegradation rates, affecting the widest range of CAHs, occur under methanogenic conditions (Bouwer, 1994). Dehalogenation of PCE and TCE to DCE can proceed under mildly reducing conditions such as nitrate reduction or iron (III) reduction (Vogel *et al.*, 1987), while the transformation of DCE to vinyl chloride, or the transformation from vinyl chloride to ethene requires more strongly reducing conditions (Freedman and Gossett, 1989; DeStefano *et al.*, 1991; DeBruin *et al.*, 1992). Given a high dissolved methane concentration in the core of the WP-15 contaminant plume (8.5 mg/L in the IW-3 groundwater sample), conditions appear to be sufficiently reducing within the WP-15 portion of Zone 1 to support reductive dechlorination from *cis*-1,2-DCE to vinyl chloride, and potentially further to ethene.

Fortuitously, the degree of sorption of chlorinated solvents to organic matter in soil is proportional to the amount of chlorine in the molecule. Consequently, the compounds with more chlorine (e.g., PCE, TCE, and DCE) have slower contaminant velocities due to increased retardation in the presence of organic matter. This can result in a longer residence time in the highly reducing anaerobic core for chlorinated solvent compounds containing the most chloride. Once again, this zone is most favorable for the degradation of highly chlorinated compounds. Conversely, solvents with fewer chlorine atoms travel more rapidly through the anaerobic regions of the plume and into the aerobic fringe, thereby bringing these compounds into the region most favorable to their degradation, as described in Section 4.3.3.2.

Because CAH compounds are used as electron acceptors, there must be an appropriate source of carbon for microbial growth in order for reductive dehalogenation to occur (Bouwer, 1994). Potential carbon sources can include low-molecular-weight

compounds (e.g., lactate, acetate, methanol, or glucose) present in natural organic matter, or fuel hydrocarbons such as BTEX.

4.3.3.2 Electron Donor Reactions

Under aerobic conditions some CAH compounds can be utilized as the primary substrate (i.e., electron donor) in biologically mediated redox reactions (McCarty and Semprini, 1994). In this type of reaction, the facilitating microorganism obtains energy and organic carbon from the degraded CAH. In contrast to reactions in which the CAH is used as an electron acceptor, only the least oxidized CAHs can be utilized as electron donors in biologically mediated redox reactions. Davis and Carpenter (1990) describe the aerobic oxidation of vinyl chloride in groundwater. McCarty and Semprini (1994) describe investigations in which vinyl chloride was shown to serve as a primary substrate. These authors also document that dichloromethane has the potential to function as a primary substrate under either aerobic or anaerobic environments. In addition, Bradley and Chapelle (1996) show evidence of oxidation of vinyl chloride under iron-reducing conditions so long as there is sufficient bioavailable iron (III). Klier *et al* (1996) provide evidence to suggest that DCE can be aerobically biodegraded in both contaminated soils and groundwater. Klier *et al.* write that naturally occurring microorganisms in soil and groundwater are capable of biodegrading DCE contamination, by using DCE as a primary substrate (i.e. and electron donor). Murray and Richardson (1993) write that microorganisms are generally believed to be incapable of growth using TCE and PCE. Aerobic oxidation of vinyl chloride and DCE may be characterized by loss of contaminant mass, a decreasing molar ratio of vinyl chloride and DCE to other CAH compounds, and the presence of elevated CO_2 concentrations.

At Zone 1, both *cis*-1,2-DCE and vinyl chloride concentrations are attenuated downgradient from the WP-15 portion of the site. This is supported by the disappearance of vinyl chloride concentrations, the reduction in *cis*-1,2-DCE concentrations, and the decrease in the molar ratio of dissolved DCE to source solvents

(PCE plus TCE). In the core of the WP-15 site at monitoring well IW-3, the molar ratio was approximately 37 to 1; however, downgradient at well MP-11D, the molar ratio was approximately 1 to 2. Theoretically, this observation would be supported by an increase in DO concentration in the 1,000 feet separating the two points; however, groundwater data could not be obtained in this area during the TS investigation because of the presence of the concrete aircraft apron.

4.3.3.3 Cometabolism

When a CAH is biodegraded through cometabolism, it serves as neither an electron acceptor nor a primary substrate in a biologically mediated redox reaction. Instead, the degradation of the CAH is catalyzed by an enzyme or cofactor that is fortuitously produced by organisms for other purposes. The organism receives no known benefit from the degradation of the CAH; rather the cometabolic degradation of the CAH may in fact be harmful to the microorganism responsible for the production of the enzyme or cofactor (McCarty and Semprini, 1994).

Cometabolism is best documented in aerobic environments, although it potentially could occur under anaerobic conditions. It has been reported that under aerobic conditions chlorinated ethenes, with the exception of PCE, are susceptible to cometabolic degradation (Murray and Richardson, 1993; Vogel, 1994; McCarty and Semprini, 1994). Vogel (1994) further elaborates that the cometabolism rate increases as the degree of dehalogenation decreases. There is no evidence to either support or disallow that dissolved TCE, and *cis*-DCE concentrations are being reduced through cometabolic processes.

SECTION 5

GROUNDWATER MODEL

5.1 GENERAL OVERVIEW AND MODEL DESCRIPTION

In order to help estimate degradation rates for dissolved benzene at Zone 1 and to help predict the future migration of these compounds, Parsons ES numerically modeled the fate and transport of the dissolved BTEX plume. The modeling effort had three primary objectives: 1) predict the future extent and concentration of the dissolved contaminant plume by modeling the combined effects of biodegradation, advection, dispersion, and sorption; 2) assess the potential for exposure of downgradient receptors to contaminant concentrations that exceed regulatory standards intended to be protective of human health and the environment; and 3) provide further technical support for the evaluation of the RNA option. The models were developed using site-specific data and conservative assumptions about governing physical and chemical processes. Due to the conservative nature of the model input, the reduction in contaminant mass resulting from natural attenuation is expected to exceed model predictions. This analysis is not intended to represent a baseline assessment of potential risks posed by site contamination.

The Bioplume II code was used to estimate the potential for dissolved BTEX migration and degradation by natural mechanisms operating at Zone 1. The Bioplume II model incorporates advection, dispersion, sorption, and biodegradation to simulate contaminant plume migration and degradation. The model is based upon the USGS Method of Characteristics (MOC) two-dimensional (2-D) solute transport model of Konikow and Bredehoeft (1978). The model was modified by researchers at Rice University to include a biodegradation component that can be activated by a

superimposed DO plume. On the basis of the work of Borden and Bedient (1986), the model assumes a reaction between DO and BTEX that is instantaneous relative to the advective groundwater velocity. Bioplume II solves the USGS 2-D solute transport equation twice, once for hydrocarbon concentrations in the aquifer and once for a DO plume. The two plumes are combined using superposition at every particle move to simulate the instantaneous biologically mediated reaction between hydrocarbons and oxygen.

In recent years it has become apparent that anaerobic processes such as denitrification, iron reduction, sulfate reduction, and methanogenesis can be important BTEX degradation mechanisms (Grbic´-Galic´, 1990; Beller *et al.*, 1992; Edwards *et al.*, 1992; Edwards and Grbic´-Galic´, 1992; Grbic´-Galic´ and Vogel, 1987; Lovley *et al.*, 1989; Hutchins, 1991). Because geochemical evidence supports the occurrence of anaerobic biodegradation processes at Zone 1 (Section 4.4.2), the combined processes of aerobic and anaerobic biodegradation were considered in calculating BTEX fate and transport at the site. The following subsections discuss in detail the input parameters, the model assumptions, the model calibration, and the simulation results.

5.2 CONCEPTUAL MODEL DESIGN AND ASSUMPTIONS

Prior to developing a groundwater model, it is important to determine if sufficient data are available to provide a reasonable estimate of aquifer conditions. In addition, it is important to ensure that any limiting assumptions can be justified. The most important assumption made when using the Bioplume II model is that electron-acceptor-limited biodegradation of fuel hydrocarbons is occurring at the site. The Bioplume II model assumes that the limiting factors for BTEX biodegradation are: 1) the presence of an indigenous hydrocarbon-degrading microbial population, and 2) sufficient background electron acceptor concentrations. Data and information presented in Sections 3 and 4 suggest that oxygen, nitrate, ferric hydroxide, sulfate, and carbon

dioxide (methanogenesis) are being used as electron acceptors for aerobic and anaerobic biodegradation of BTEX.

On the basis of the data presented in Section 3, the shallow aquifer is defined vertically by medium to coarse sands interbedded with a silty fine sand. The majority of dissolved BTEX contamination preferentially migrates from the source areas in the medium to coarse sand. However, vertical migration of dissolved contamination within the shallow unconsolidated aquifer also is occurring. This transport process was incorporated into the model by calibrating the model to the highest observed contaminant concentrations regardless of depth and assuming contamination is distributed evenly throughout the aquifer. Dissolved BTEX migrates horizontally in the shallow aquifer with a slight downward trend until a preferred horizontal flow path through the coarse sands dominates. Lithologic data from soil borings suggest that the base of the shallow unconsolidated aquifer is defined by the top of the silt and clay aquitard at approximately 60 to 70 feet bgs. Groundwater enters the site from the northwest. Groundwater elevations suggest that the shallow groundwater at the site flows to the southeast near Hanger 7040 and south-southwestward beneath the grassy area between the runway and the aircraft apron (Figure 3.4). Changes in groundwater recharge associated with the irrigated grasses and the concrete aircraft parking apron may be responsible for variations in groundwater flow direction across the site.

The shallow unconsolidated aquifer above the silt and clay aquitard was conceptualized and modeled as an unconfined aquifer composed of medium to coarse sand (Figures 3.2, 3.3, and 3.4). The average saturated thickness of this layer was estimated at 40 feet. The use of a 2-D model is appropriate at the Zone 1 site because the shallow saturated interval (acting as the dominant transport pathway) is relatively thin and homogeneous. Although dissolved BTEX appears to migrate horizontally with a vertical component, vertical contaminant migration appears to be mostly limited to the modeled 40-foot-thick shallow aquifer; therefore, using a 2-D model in conjunction

with the highest observed BTEX concentration at vertical well clusters will yield estimates for the highest anticipated concentrations.

Dissolved BTEX is believed to have originated from residual soil contamination present in the shallow soils surrounding the fuel storage and distribution systems. A soil bioventing pilot test performed at SS-16 in 1994 successfully remediated contaminated soil at the site (Parsons ES, 1994). However, recent undocumented spills or leaks may be responsible for mobile LNAPL measured in well ECS-26 in September 1996. Soil surrounding the former JP-4 tanks at site SS-19 was combined with clean backfill when the tanks were removed in 1991. No active remediation has been performed on the contaminated backfill; however, the soil sampling results from this investigation and the OB&G (1997) Phase II IRP investigation suggest natural biodegradation has reduced soil contamination to levels that are below Massachusetts Contingency Plan (MCP) S-1 standards. Given the removal of damaged USTs and the modernization of existing USTs and distribution lines, additional fuel releases are not expected at the site in the future; therefore, only BTEX contamination leaching from current residual fuel contamination in site soils and the mobile LNAPL at Site SS-16 were considered as a continuing source for the dissolution of BTEX into groundwater over time.

5.3 INITIAL MODEL SETUP

The setup for this model was based on available site data. Where site-specific data were not available (e.g., effective porosity), reasonable assumptions for the types of materials that make up the shallow aquifer were made on the basis of widely accepted literature values. The following sections describe the basic model setup. Those Bioplume II model parameters that were varied during model calibration are discussed in Section 5.4.

5.3.1 Grid Design and Boundary Conditions

The maximum grid size for the Bioplume II model is limited to 50 columns by 100 rows. The dimension of each column and row can range from 0.1 to 999.9 feet. A 40- by 40-cell grid was used to model Zone 1. Each grid cell was 100 feet long by 100 feet wide. The grid includes the existing BTEX plumes and encompasses an area of 16,000,000 square feet (approximately 365 acres). The full extent of the model grid is indicated on Figure 5.1.

Model boundaries are mathematical statements that represent hydrogeologic boundaries, such as areas of specified head (i.e., surface water bodies or contour lines of constant hydraulic head) or specified flux. Hydrogeologic boundaries are represented by three mathematical statements that describe the hydraulic head at the model boundaries. These include:

- Specified-head boundaries (Dirichlet condition) for which the head is determined as a function of location and time only. Surface water bodies exhibit constant-head conditions. Specified-head boundaries are expressed mathematically as:

$$Head = f(x,y,z,t)$$

  where f is the function symbol, x, y, and z are position coordinates, and t is time.

- Specified-flow boundaries (Neumann conditions) for which the mathematical description of the flux across the boundary is given. The flux is defined as a volumetric flow rate per unit area (i.e., $ft^3/ft^2/day$). No-flow boundaries are a special type of specified-flow boundary and are set by specifying the flux to be zero. Examples of no-flow boundaries include groundwater divides and impermeable hydrostratigraphic units. Specified-flux boundaries are expressed mathematically as:

$$Flux = f(x,y,z,t)$$

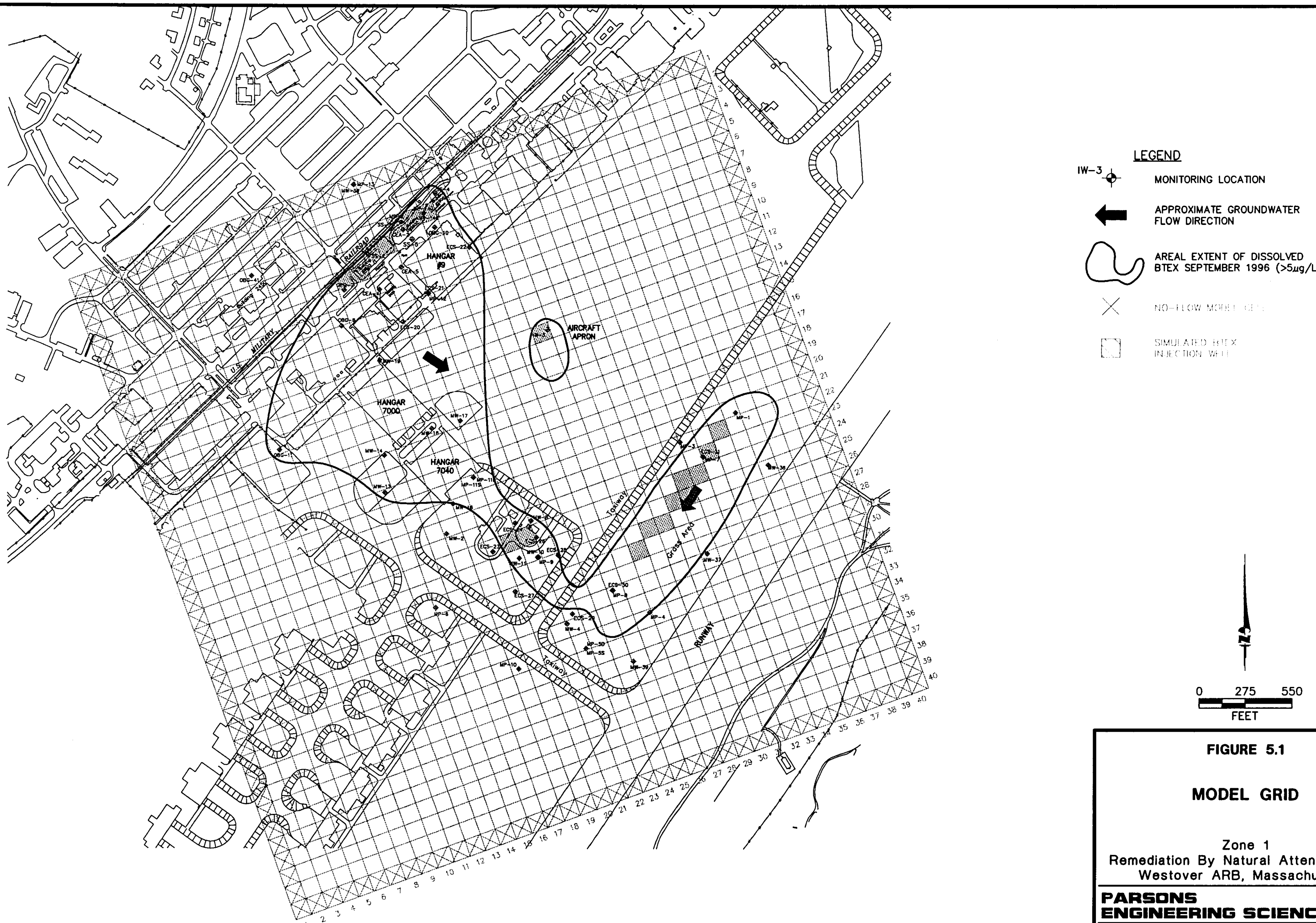

FIGURE 5.1

MODEL GRID

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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- Head-dependent flow boundaries (Cauchy or mixed-boundary conditions) where the flux across the boundary is calculated from a given boundary head value. This type of flow boundary is sometimes referred to as a mixed-boundary condition because it is a combination of a specified-head boundary and a specified-flow boundary. Head-dependent flow boundaries are used to model leakage across semipermeable boundaries. Head-dependent flow boundaries are expressed mathematically as (Bear, 1979):

$$Flux = \frac{(H_0 - H)K'}{B'}$$

Where: H = Head in the zone being modeled (generally the zone containing the contaminant plume),

H_0 = Head in external zone (separated from plume by semipermeable layer),

K' = Hydraulic conductivity of semipermeable layer, and

B' = Thickness of semipermeable layer.

Natural hydraulic boundaries are modeled using a combination of the three types of model boundary conditions listed above. When possible, hydrologic boundaries such as surface water bodies, groundwater divides, contour lines, or hydrologic barriers should coincide with the perimeter of the model. In areas lacking obvious hydrologic boundaries, specified-head or specified-flux boundaries can be used at the model perimeter if the boundaries are far enough removed from the contaminant plume that transport calculations are not affected. Bioplume II requires the entire model domain to be bounded by zero-flux cells (also known as no-flow cells), with other boundary conditions established within the subdomain specified by the no-flow cells.

Based on the lack of natural hydrogeologic boundaries and shifting groundwater flow directions at Zone 1, specified-head boundaries were established on all sides of the

model grid. In 2-D models, a row of specified-head boundaries at the up- and downgradient ends of the model grid typically are sufficient to simulate the flow of groundwater for sites that are not hydrogeologically complex or are bounded by adjacent lakes or streams. The head at the northern boundary was estimated to be from 230.75 to 227.9 feet above msl, and represents the level of groundwater in this portion of the site in September 1996. The heads along the eastern model boundary ranged from 220.1 to 215.4 feet msl.

The base or lower boundary of the model is assumed to be no-flow, and is defined by the upper surface of the varved silt and clay aquitard layer located approximately 65 feet bgs. The upper model boundary is defined by the simulated water table surface, at approximately 20 to 25 feet bgs.

5.3.2 Groundwater Elevation and Gradient

The September 1996 water table elevation map, presented in Figure 3.4, was used to define the heads used as initial input into the Bioplume II model. Groundwater flow at Zone 1 varies from south-southeast to south-southwest, with a gradient range over the modeled area of approximately 0.003 ft/ft to 0.005 ft/ft. Gradients are lowest in the vicinity of Hanger 7000 and highest in the vicinity of Taxiway A near the southern portion of the modeled area.

5.3.3 BTEX Concentrations

As noted in Section 5.2, dissolved BTEX enters groundwater at Zone 1 source areas through two ongoing processes: contact between groundwater and residual LNAPL at or below the water table in the source area, and migration of recharge (precipitation) through soil containing residual LNAPL above the water table. The total dissolved BTEX concentrations obtained from laboratory analytical results for each well and monitoring point location were used for model development. At multidepth groundwater sampling locations, the higher BTEX concentration was selected to represent concentrations in the shallow aquifer. Table 4.3 presents dissolved BTEX

concentration data. Figure 4.2 shows the areal distribution of dissolved BTEX compounds in shallow groundwater in September 1996.

5.3.4 Biodegradation Rates

Available data strongly suggest that anaerobic degradation is occurring at the site, with combined anaerobic processes accounting for about 78 percent of the BTEX assimilative capacity of site groundwater (Table 4.6). Anaerobic degradation must therefore be simulated with Bioplume II to make meaningful predictions. The Bioplume II model simulates anaerobic biodegradation by assuming that such degradation follows first-order kinetics. As with a large number of biological processes, anaerobic biodegradation can generally be described using a first-order rate constant and the equation:

$$\frac{C}{C_0} = e^{-kt}$$

Where: C = Contaminant Concentration at Time t,

C_0 = Initial Contaminant Concentration,

k = Coefficient of Anaerobic Decay (anaerobic rate constant),

t = time.

Buscheck and Alcantar (1995) derive a relationship that allows calculation of first-order decay rate constants for steady-state plumes. This method involves coupling the regression of contaminant concentration (plotted on a logarithmic scale) versus distance downgradient (plotted on a linear scale) to an analytical solution for one-dimensional, steady-state, contaminant transport that includes advection, dispersion, sorption, and biodegradation (Bear, 1979). For a steady-state plume, the first-order decay rate is given by (Buscheck and Alcantar, 1995):

$$\lambda = \frac{v_c}{4\alpha_x}\left(\left[1 + 2\alpha_x\left(\frac{k}{v_x}\right)\right]^2 - 1\right)$$

Where: λ = first-order decay rate,

v_c = retarded contaminant velocity in the x-direction,

α_x = dispersivity, and

k/v_x = slope of line determined from a log-linear plot of contaminant concentration versus distance downgradient along flow path.

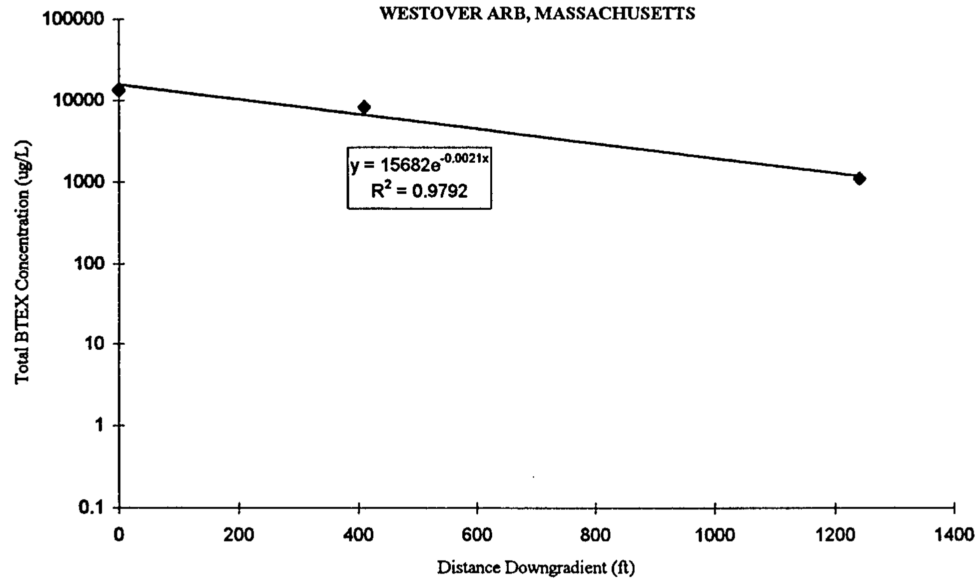
The first-order decay rate includes biodegradation resulting from both aerobic and anaerobic processes; however, in the absence of oxygen, the first-order rate is equivalent to the anaerobic decay rate. Table 5.1 presents a first-order rate constant calculation for BTEX using September 1996 data at Zone 1 and the method proposed by Buscheck and Alcantar (1995). A south-southeasterly groundwater flow path through sampling locations MP-14S, ECS-21, and MW-17 was used for estimating a biodegradation rate. This flow path represents an anaerobic groundwater travel path for the plume originating at the former SS-19 source area to the downgradient extents of the plume prior to mingling with the SS-16 plume. An exponential fit to the data estimates a log-linear slope of 0.0021 foot^{-1}, which was in turn used to estimate a decay constant of 0.0007 day^{-1}. The calculated correlation coefficient of 0.979 demonstrates that the use of a first-order biodegradation rate is acceptable.

A review of recent literature indicates that similar anaerobic rate constants generally have been calculated at other sites. For example, Chapelle (1994) reported that at two different sites with anaerobic groundwater conditions, the anaerobic rate constants were both approximately 0.01 day^{-1}. Wilson *et al.* (1994) reported first-order anaerobic biodegradation rates of 0.05 to 1.3 week^{-1} (0.007 to 0.185 day^{-1}); Buscheck *et al.* (1993) report first-order attenuation rates in a range of 0.001 to 0.01 day^{-1}; and

TABLE 5.1
FIRST-ORDER RATE CONSTANT CALCULATION
USING THE METHOD OF BUSCHECK AND ALCANTAR (1995)
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Point	Distance Downgradient(ft)	Total BTEX (μg/L) Sep-95
MP-14S	0	13560
ECS-21	410	8300
MW-17	1240	1104.7

PLOT OF TOTAL BTEX CONCENTRATION VERSUS DISTANCE
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS



$\lambda = v_c/4\alpha_x([1+2\alpha_x(k/v_x)]^2-1)$

where	v_c =	0.290	ft/day
	α_x =	100	ft
	k/v =	0.0021	ft-1
therefore	λ =	0.0007	day-1

Stauffer *et al.* (1994) report rate constants of 0.01 and 0.018 day^{-1} for benzene and *p*-xylene, respectively. In the groundwater model, a calibrated anaerobic rate constant of 0.0005 day^{-1} was used for this site and is below the range reported in the literature. Therefore, this selected biodegradation rate is considered to be very conservative when compared to the literature values.

5.3.5 Dispersivity

Much controversy surrounds the concepts of dispersion and dispersivity. Longitudinal dispersivity values for saturated deposits similar to those found at the site range from 0.1 to 200 feet (Walton, 1988). During plume calibration, longitudinal dispersivity was varied from 60 to 140 feet. Longitudinal dispersivity was estimated using approximately one-tenth (0.1) of the length of each plume from the source area to the downgradient extent (Figure 4.2). Using this relationship, the SS-16 plume was estimated to have a longitudinal dispersivity of 140 feet. The SS-19 plumes were estimated to have dispersivities of 60 and 120 feet, respectively. Therefore, a longitudinal dispersivity of 100 feet was used in the calibated model. Transverse dispersivity values generally are estimated as one-tenth (0.1) of the longitudinal dispersivity values (Domenico and Schwartz, 1990). For this model, the ratio of transverse dispersivity to longitudinal dispersivity was maintained at 0.1 to reproduce the plume width observed at the site.

5.3.6 Coefficient of Retardation

Retardation of the BTEX compounds relative to the advective velocity of the groundwater occurs when BTEX molecules are sorbed to the aquifer matrix. The coefficients of retardation for the BTEX compounds were calculated on the basis of measured TOC concentrations in soils collected from and near the saturated zone at uncontaminated boreholes at the site, an assumed bulk density of 1.65 grams per cubic centimeter (g/cc) (Domenico and Schwartz, 1990), and published values of the soil sorption coefficients (K_{oc}) for the BTEX compounds, as listed by Wiedemeier *et al.* (1995). Because there is only limited retardation of the BTEX plume at Zone 1, the

influx of electron acceptors through the plume is reduced, and biodegradation mechanisms have a smaller affect on the BTEX plume fate.

TOC analyses often are influenced by the presence of soil hydrocarbon contamination, which may cause high soil TOC concentrations without necessarily reflecting an increase in the sorptive potential of soil. Therefore, TOC measurements used for retardation estimates should be taken from contaminant-free soils. Furthermore, TOC values should be measured across the water table rather than in the vadose zone to best represent the sorptive potential of saturated soils in the aquifer. Thirteen locations were sampled for TOC analyses at Zone 1 (Table 4.1). Of the 13 samples, only 3 had TOC concentrations greater than the quantification limit. The three samples were collected in contaminated soils near or below the water table at boreholes MP-2, SS-2, and SS-4, and had TOC concentrations ranging from 0.20 to 0.55 percent. Therefore, the retardation was estimated to be 1 for Zone 1 because TOC was not detected in the uncontaminanted portions of the aquifer. This value is conservative and estimates a maximum contaminant transport distance because the BTEX compounds are not retarded. With the BTEX compounds and groundwater migrating at the same velocity, the biodegradation rate is reduced because the influx of available upgradient electron acceptors (i.e., DO) into the contaminant plume is not occurring.

5.4 MODEL CALIBRATION

Model calibration is an important component in the development of any numerical groundwater model. Calibration of the flow model demonstrates that the model is capable of matching hydraulic conditions observed at the site; calibration of a contaminant transport model superimposed upon the calibrated flow model helps verify that contaminant loading and transport conditions are being appropriately simulated. The numerical flow model presented herein was calibrated by altering transmissivity and constant-head boundary conditions in a trial-and-error fashion until simulated heads approximated observed field values within a prescribed accuracy. After calibration of

the flow model, the numerical transport model was calibrated by estimating and adjusting the BTEX source loading and transport parameters in a trial-and-error fashion until the simulated BTEX plume approximated observed field values. Table 5.2 lists input parameters used for the modeling effort. Model input and output files are included in Appendix D.

5.4.1 Water Table Calibration

The shallow water table at Zone 1 was assumed to be influenced by continuous recharge and discharge at the constant-head cells surrounding the model grid. The initial water levels at the constant-head cells and the transmissivity values were varied to calibrate the water table surface. The model was calibrated under steady-state conditions.

Hydraulic conductivity is an important aquifer characteristic that determines the ability of the water-bearing strata to transmit groundwater. Transmissivity is the product of the hydraulic conductivity and the thickness of the aquifer. An accurate estimate of hydraulic conductivity is important to help quantify advective groundwater flow velocities and to define the flushing potential of the aquifer and the quantity of electron-acceptor-charged groundwater that is entering the site from upgradient locations. According to the work of Rifai *et al.* (1988), the Bioplume II model is particularly sensitive to variations in hydraulic conductivity. Lower values of hydraulic conductivity result in a slower-moving plume with a relatively small areal extent and a higher average BTEX concentration. Higher values of hydraulic conductivity result in a faster-moving plume that is spread over a larger area and contains lower average BTEX concentrations.

Saturated thickness data from previous reports, geologic logs, and water level measurements were used in conjunction with the hydraulic conductivity estimates to create an initial transmissivity grid for the entire model. To better match heads in the model to observed values, the transmissivities were progressively varied in blocks and rows until the simulated water levels for cells corresponding to selected well locations

TABLE 5.2
BIOPLUME II MODEL INPUT PARAMETERS
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Parameter	Description	Calibrated Model Setup	Model RNA	Model Passive	Model Slurping
NTIM	Maximum number of time steps in a pumping period	5	5	5	5
NPMP	Number of Pumping Periods	23	68	68	68
NX	Number of nodes in the X direction	40	40	40	40
NY	Number of nodes in the Y direction	40	40	40	40
NPMAX	Maximum number of Particles: NPMAX= (NX-2)(NY-2)(NPTPND) + (Ns[a])(NPTPND) + 250	14083	14083	14083	14083
NPNT	Time step interval for printing data	1	1	1	1
NITP	Number of iteration parameters	7	7	7	7
NUMOBS	Number of observation points	0	0	0	0
ITMAX	Maximum allowable number of iterations in ADIP [b]	200	200	200	200
NREC	Number of pumping or injection wells	22	22	22	22
NPTPND	Initial number of particles per node	9	9	9	9
NCODES	Number of node identification codes	1	1	1	1
NPNTMV	Particle movement interval (IMOV)	0	0	0	0
NPNTVL	Option for printing computed velocities	1	1	1	1
NPNTD	Option to print computed dispersion equation coefficients	1	1	1	1
NPDELC	Option to print computed changes in concentration	1	1	1	1
NPNCHV	Option to punch velocity data	0	0	0	0
NREACT	Option for biodegradation, retardation and decay	1	1	1	1
PINT	Pumping period (years)	28	73	73	73
TOL	Convergence criteria in ADIP	0.001	0.001	0.001	0.001
POROS	Effective porosity	0.25	0.25	0.25	0.25
BETA	Characteristic length (long. dispersivity; feet)	100	100	100	100
S	Storage Coefficient	0 (Steady-State)	0 (Steady-State)	0 (Steady-State)	0 (Steady-State)
TIMX	Time increment multiplier for transient flow	-	-	-	-
TINIT	Size of initial time step (seconds)	-	-	-	-
XDEL	Width of finite difference cell in the x direction (feet)	100	100	100	100
YDEL	Width of finite difference cell in the y direction (feet)	100	100	100	100
DLTRAT	Ratio of transverse to longitudinal dispersivity	0.1	0.1	0.1	0.1
CELDIS	Maximum cell distance per particle move	0.5	0.5	0.5	0.5
ANFCTR	Ratio of Tyy to Txx (1 = isotropic)	1	1	1	1
DK	Distribution coefficient	0.0	0.0	0.0	0.0
RHOB	Bulk density of the solid (grams/cubic centimeter)	1.65	1.65	1.65	1.65
THALF	Half-life of the solute	-	-	-	-
DEC1	Anaerobic decay coefficient (day^{-1})	0.0005	0.0005	0.0005	0.0005
DEC2	Reaeration coefficient (day^{-1})	0.0	0.0	0.0	0.0
F	Stoichiometric Ratio of Hydrocarbons to Oxygen	3.14	3.14	3.14	3.14

[a] Ns = Number of nodes that represent fluid sources (wells or constant head cells).

[b] ADIP = Alternating-direction implicit procedure (subroutine for solving groundwater flow equation).

matched the observed water levels as closely as possible. Figure 5.2 shows the calibrated water table.

The calibrated model hydraulic conductivity ranged from 1.34 x 10^{-4} foot per second (ft/sec) to 3.5 x 10^{-4} ft/sec (11.6 ft/day to 30.2 ft/day). This range is similar to the measured hydraulic conductivity range of 8.3 ft/day to 42 ft/day presented in Section 3.3.2. Hydraulic conductivity was varied through this range of values using the stratigraphy of the saturated zone as a guide to help achieve a reasonable representation of the observed groundwater table at the site.

A calibrated precipitation recharge rate of 3.3 inches per year was assumed to enter the aquifer in the grassy areas at Zone 1. This is equivalent to approximately 8 percent of the annual precipitation at Westover ARB. Zero recharge was simulated beneath buildings and the concrete aircraft apron.

Water level elevation data from cells associated with 32 groundwater monitoring locations were used to compare measured and simulated heads for calibration. The 32 selected cell locations each contained one of the following shallow monitoring wells: CEA-2, CEA-4, CEA-5, ECS-22, ECS-23, ECS-24, ECS-26, ECS-27, ECS-28, ECS-30, ECS-31, MP-1, MP-2, MP-3, MP-4, MP-10, MP-11S, MP-14S, MW-8, MW-11, MW-13, MW-14, MW-16, MW-19, MW-36, MW-37, MW-39, OBG-7, OBG-8, OBG-10, OBG-11, and OBG-41.

The root mean square (RMS) error is commonly used to express the average difference between simulated and measured heads. RMS error is the average of the squared differences between measured and simulated heads, and can be expressed as:

$$\mathrm{RMS} = \left[\frac{1}{n} \sum_{i=1}^{n} \left(h_m - h_s \right)_i^2 \right]^{0.5}$$

Where: n = the number of points where heads are being compared,
h_m = measured head value (feet above msl), and
h_s = simulated head value (feet above msl).

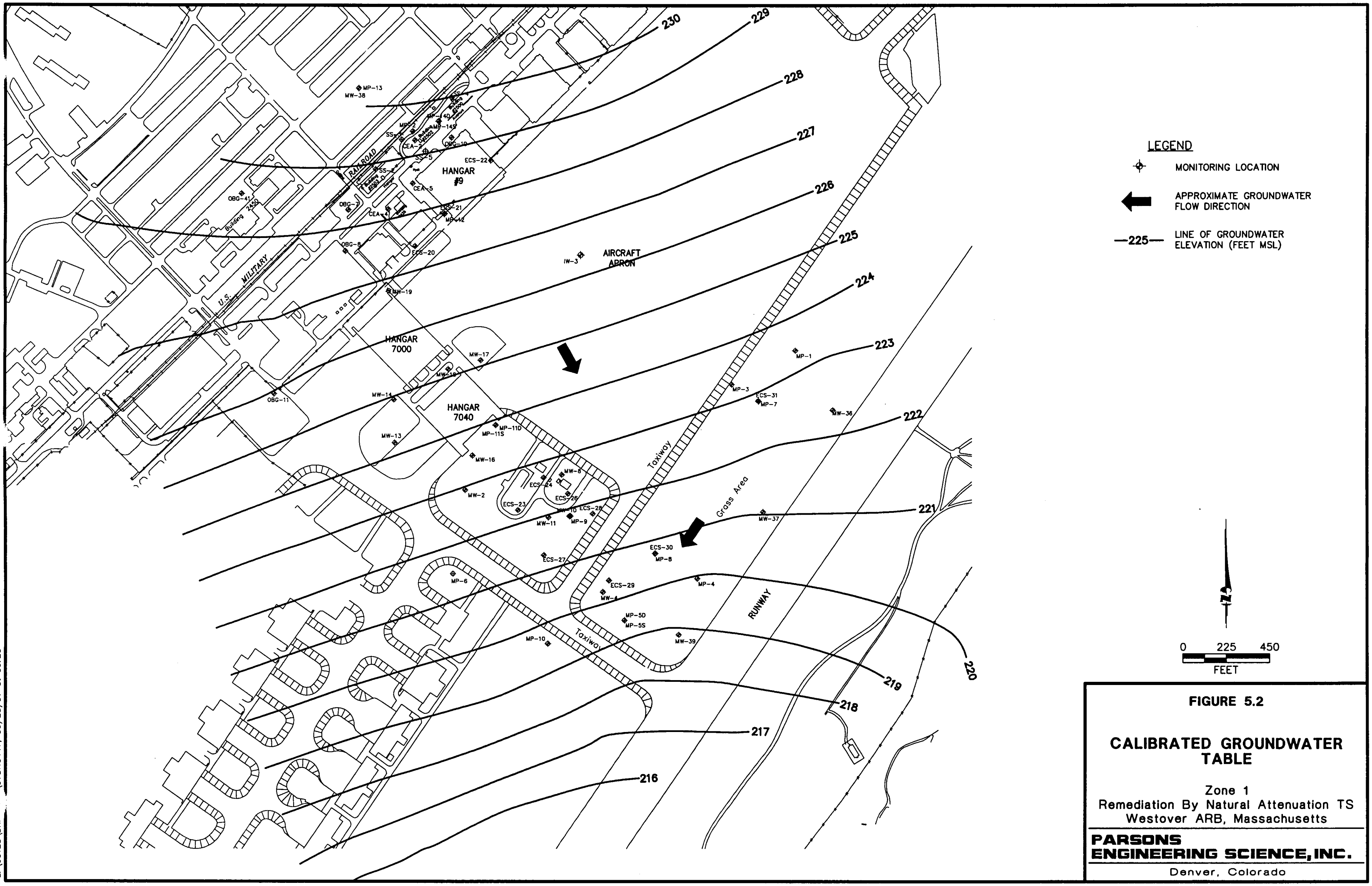


FIGURE 5.2

CALIBRATED GROUNDWATER TABLE

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

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The RMS error between observed and calibrated values at the 32 comparison points was 0.72 foot, which corresponds to a calibration error of 4.6 percent (water levels dropped 15.75 feet over the length of the model grid). RMS error calculations are summarized in Appendix C. A plot of measured versus calibrated heads shows a random distribution of points around a straight line, as shown in Appendix C. Deviation of points from a straight line should be randomly distributed in such a plot of results from computer simulations (Anderson and Woessner, 1992).

In solving the groundwater flow equation, Bioplume II establishes the water table surface and calculates an overall hydraulic balance that accounts for the numerical difference between flux into and out of the system. Considering the groundwater hydraulics at the site, the hydraulic mass balance for the calibrated model was reasonable, with 99.91 percent of the water flux into and out of the system being numerically accounted for (i.e., a 0.09-percent error). According to Anderson and Woessner (1992), a mass balance error of around 1 percent is acceptable, while Konikow (1978) indicates an error of less than 0.1 percent is ideal.

5.4.2 BTEX Plume Calibration

Model input parameters affecting the distribution and concentration of the simulated BTEX plume were modified so that model predictions matched dissolved total BTEX concentrations observed in September 1996. BTEX plume calibration model runs were made using the calibrated steady-state hydraulic parameters coupled with the introduction of contaminants. Because the exact times, types, and frequencies of the fuel releases at the site are unknown, the model was calibrated to match September 1996 conditions, assuming the groundwater was first impacted approximately 30 years ago. Westover ARB records indicate that 19 USTs were installed at Site SS-19 from 1945 to 1956, and were in service through 1991. In the period from 1956 to 1988, 2 USTs were in use at the former industrial waste treatment plant (Site SP-15) located near the center of the aircraft parking apron. The USTs at SS-19 and WP-15 were removed from 1988 through 1991. In 1988, a 1,200-gallon JP-4 fuel spill occurred at

the SS-16 Site. Periodic undocumented spills and leaks at SS-16 may have occurred since 1980. The source and period of release for the dissolved BTEX plume beneath the grassy area east of Site SS-16 also is not known.

Estimated BTEX source concentrations (Section 5.3.3) were applied to simulated injection wells within 22 model cells situated in the core of areas of soil contamination to reproduce the configuration and concentrations of the groundwater BTEX plumes (Figure 5.1). While the term "injection well" suggests contaminants are being introduced at a point, Bioplume II assumes that contamination introduced at a well instantly equilibrates throughout the entire cell in which the well is located. The injection rate for the cells was set at a rate sufficiently low so that the flow calibration and water balance were not affected. Loading rates and periods were varied cell by cell as needed to reproduce the shape of the observed groundwater plume. In this manner, the potential source strength of the residual contamination was maintained while simultaneously obtaining the configuration of the observed BTEX plume (Figure 4.3).

For the modeled 31 years (1965-1996), varying amounts of BTEX were injected at 22 injection wells simulating the areas of soil contamination and former UST locations. With limited historical data regarding known fuel releases, the BTEX plume was calibrated using trial and error to simulate the start of contamination and determine approximate source concentrations. The objective of the calibration was to achieve modeled plumes that equaled or exceeded the observed plumes in terms of extent and concentration, and that effectively simulated the flow of BTEX contaminants from the source areas to the observed downgradient locations.

The model assumes that fuel leakage from the SS-19 and WP-15 tanks and associated distribution lines did not occur or impact groundwater until approximately 10 years after installation. Eleven leaching periods (1965-1980) were used in the calibration to simulate the configuration of the dissolved BTEX plumes resulting from

source areas at Sites SS-19 and WP-15. For the model period 1981 to 1988, eight leaching periods were used to simulate the beginning of groundwater contamination at the SS-16 source areas and continue the modeled releases at SS-19 and WP-15.

Source decay was initiated for each of the multiple Zone 1 source areas as site activities eliminated continuing source (e.g., leaking USTs, etc). The USTs at site WP-15 were removed in 1988, and the model assumes a 10-percent decay rate beginning in 1989 for the remaining contaminated source area soils.

At SS-19, source reduction of 5 percent per year was simulated in 1991, corresponding to the removal date of the USTs. At SS-16, a 50-percent decay rate was used to simulate the effects of a bioventing pilot test (Parsons ES, 1993) on source soils in 1992 and 1993. Soil sampling results collected during the bioventing pilot study indicate that source reduction in the SS-16 soils was successful (Section 4.2). In the vicinity of the fuel pit and lines grouped with SS-16 on the eastern side of the site, an annual weathering rate of 5 to 10 percent was selected for the calibrated plume.

The final calibrated model plume (year 31) was assumed to represent current (1996) conditions, and successfully meets these objectives, as it reproduces the observed areal extent and contaminant concentrations (Figure 5.1). The calibrated dissolved BTEX plume is shown in Figure 5.3. The calibrated plume accurately predicts migration of contamination from the source areas toward the southeast and south southwest. In the vicinity of site SS-19 well CEA-5, simulated BTEX concentrations are within 0.5 percent of the observed concentrations. At site SS-16 well MW-10, simulated BTEX concentrations are within 1.0 percent of the observed values. However, the calibrated model slightly over estimates the BTEX concentration upgradient from SS-19 and downgradient from SS-16. The fact that the model concentrations are slightly higher than observed concentrations means that additional BTEX mass is accounted for in the model simulations, and that model predictions are conservative. Variations in shape between the model and the observed plume likely are due to subsurface heterogeneities

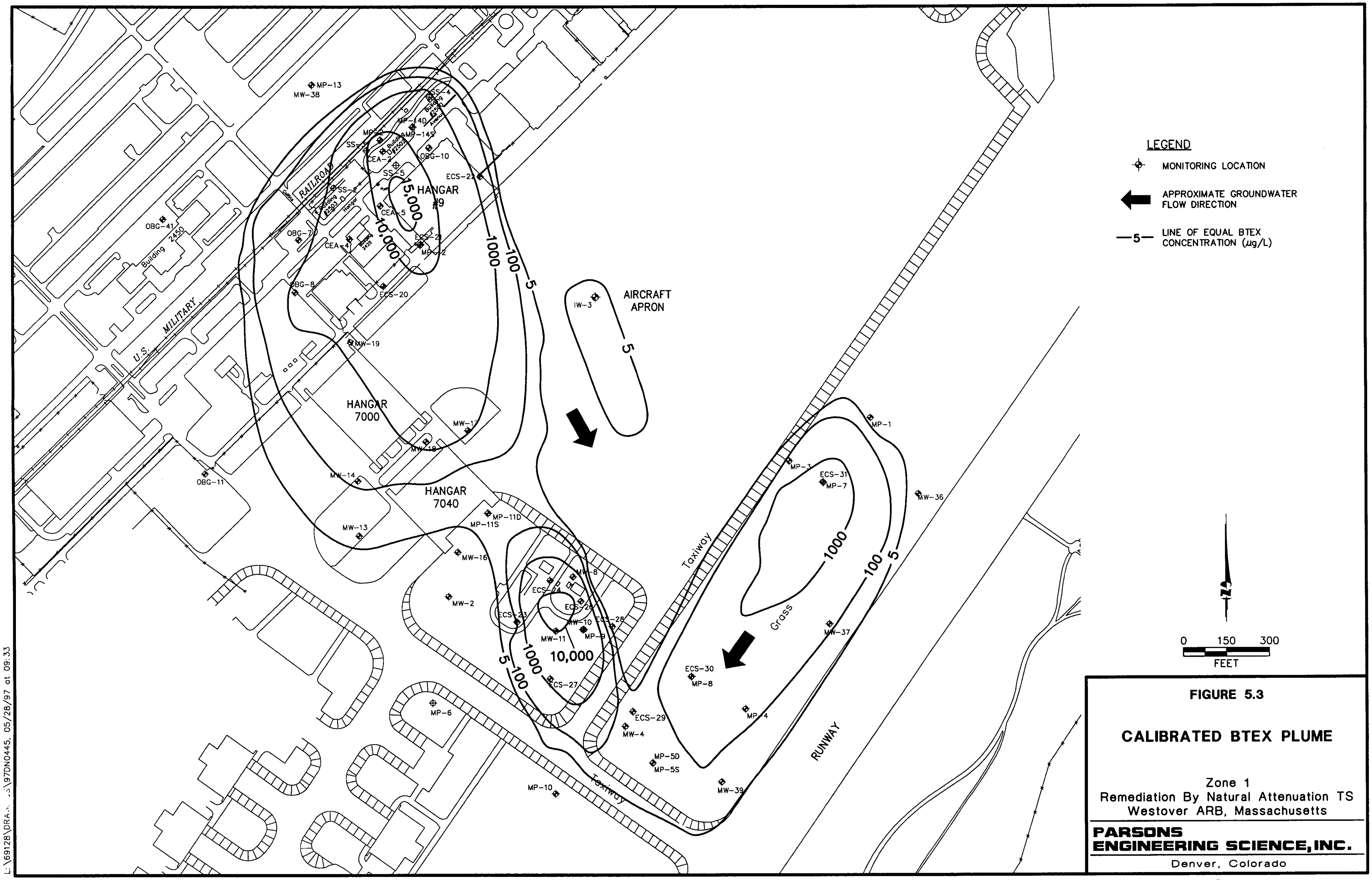

FIGURE 5.3

CALIBRATED BTEX PLUME

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

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Denver, Colorado

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in the hydraulic conductivity, anaerobic decay, dispersivity, and retardation that are extremely difficult to identify in the field and to replicate in a discretized 2-D model domain.

5.5 SENSITIVITY ANALYSIS

The purpose of a sensitivity analysis is to determine the effect of varying model input parameters on model output. According to the work of Rifai *et al.* (1988), the Bioplume II model is most sensitive to changes in the coefficient of aerobic decay (reaeration coefficient), the coefficient of anaerobic decay, and the hydraulic conductivity of the media, and is less sensitive to changes in the distribution coefficient (retardation factor), effective porosity, and dispersivity. To fully evaluate the sensitivity of the calibrated model, the transmissivity, the coefficient of anaerobic decay, the distribution coefficient, dispersivity, and effective porosity were all varied. The reaeration coefficient was not used in this model.

To perform the sensitivity analyses, the aforementioned parameters were individually and systematically varied; the model was rerun, and the results were compared to the original calibrated model. Each sensitivity model was run for a 31-year period (the same duration used in the original calibrated model) to assess the independent effect of each variable. A total of 9 sensitivity runs of the calibrated model were performed, with the following variations:

1) Transmissivity uniformly increased by a factor of 3;

2) Transmissivity uniformly decreased by a factor of 3

3) Coefficient of anaerobic decay increased by a factor of 2;

4) Coefficient of anaerobic decay decreased by a factor of 2;

5) Dispersivity increased by 50 percent;

6) Dispersivity decreased by 50 percent;

7) Effective porosity increased by 25 percent;

8) Effective porosity decreased by 25 percent; and

9) Retardation with TOC content at one-half the analytical detection limit.

The results of the sensitivity analyses are shown graphically in Figures 5.4 through 5.8. These figures display simulated BTEX concentrations versus distance downgradient from the source area. This manner of displaying data is useful because changes in BTEX concentrations can be easily visualized.

The effects of varying transmissivity are shown on Figure 5.4. When the transmissivity values are increased by a factor of three, the maximum observed BTEX concentration in the plume area was 8,510 µg/L, compared to the calibrated 15,670 µg/L. In contrast, decreasing the transmissivity by a factor of three slowed overall plume migration, which increased the maximum BTEX concentrations because of decreased dilution and spreading. The BTEX concentration in the SS-19 source area increased to approximately 38,850 µg/L. The sensitivity of the model to hydraulic conductivity suggests that appropriate transmissivity values were used in the model calibration.

The effects of varying the coefficient of anaerobic decay are illustrated by Figure 5.5. As expected, increasing this parameter by a factor of two results in a smaller plume with a maximum BTEX concentration of 10,585 µg/L. Conversely, decreasing the coefficient of anaerobic decay by a factor of two decreases the biodegradation rate and increases plume concentrations. The resultant increase raised computed maximum BTEX concentrations in the plume from 15,670 µg/L to 29,363 µg/L. These results show that the calibrated model is sensitive to variations in the coefficient of anaerobic

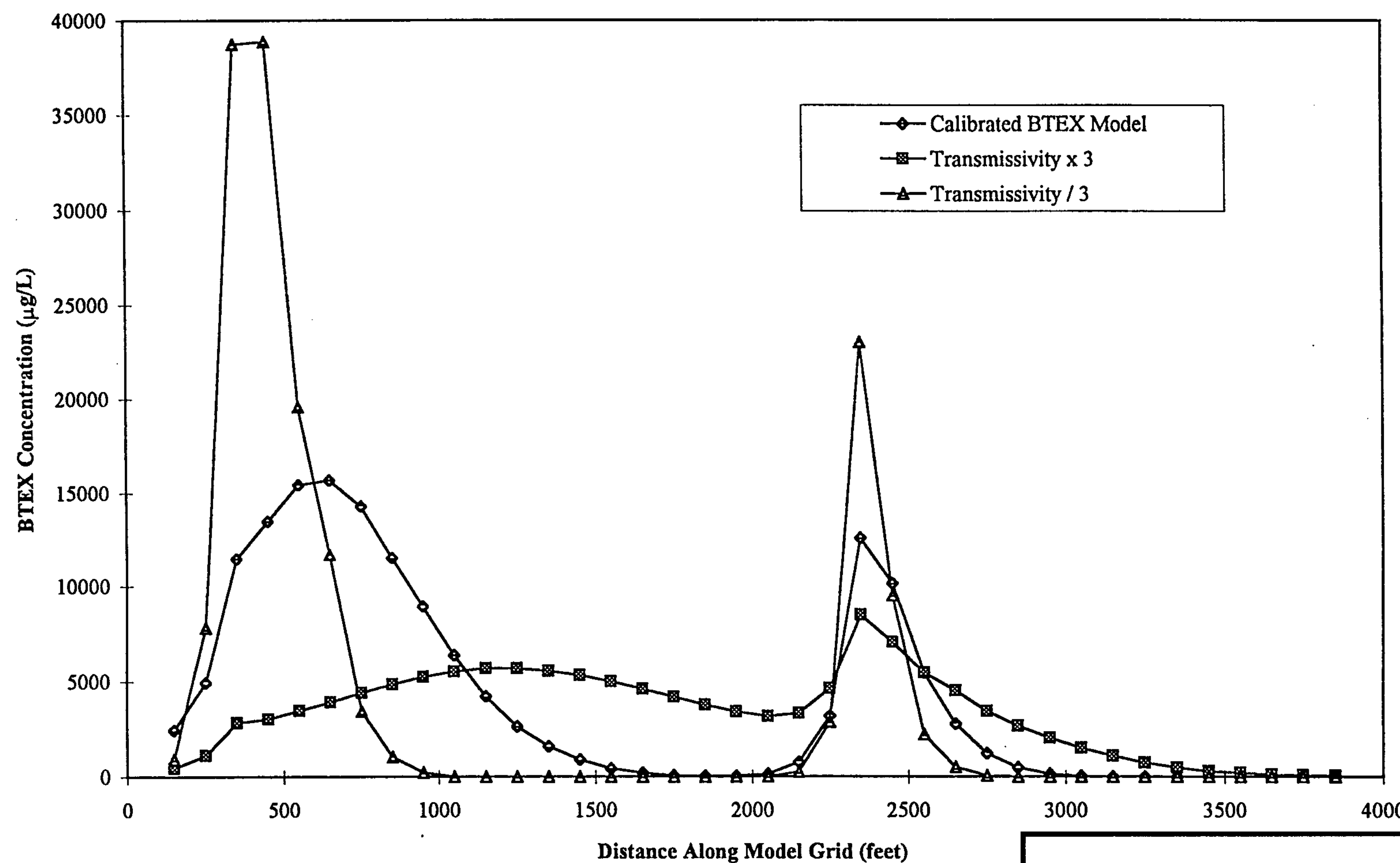

FIGURE 5.4

MODEL SENSITIVITY TO VARIATIONS IN TRANSMISSIVITY

Zone 1
Remediation by Natural Attenuation TS
Westover ARB, Massachusetts

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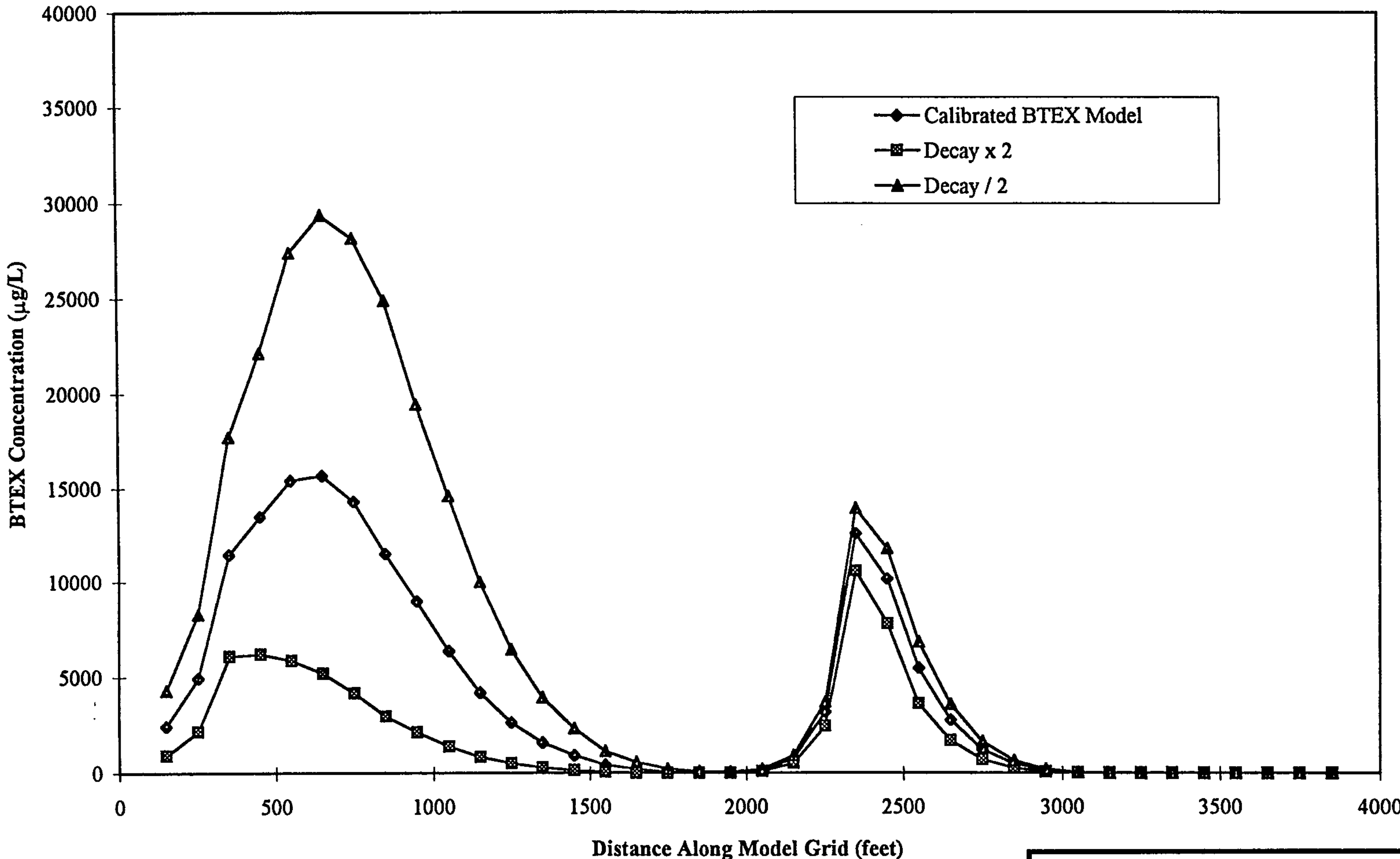

FIGURE 5.5

MODEL SENSITIVITY TO VARIATIONS IN ANAEROBIC DECAY COEFFICIENT

Zone 1
Remediation by Natural Attenuation TS
Westover ARB, Massachusetts

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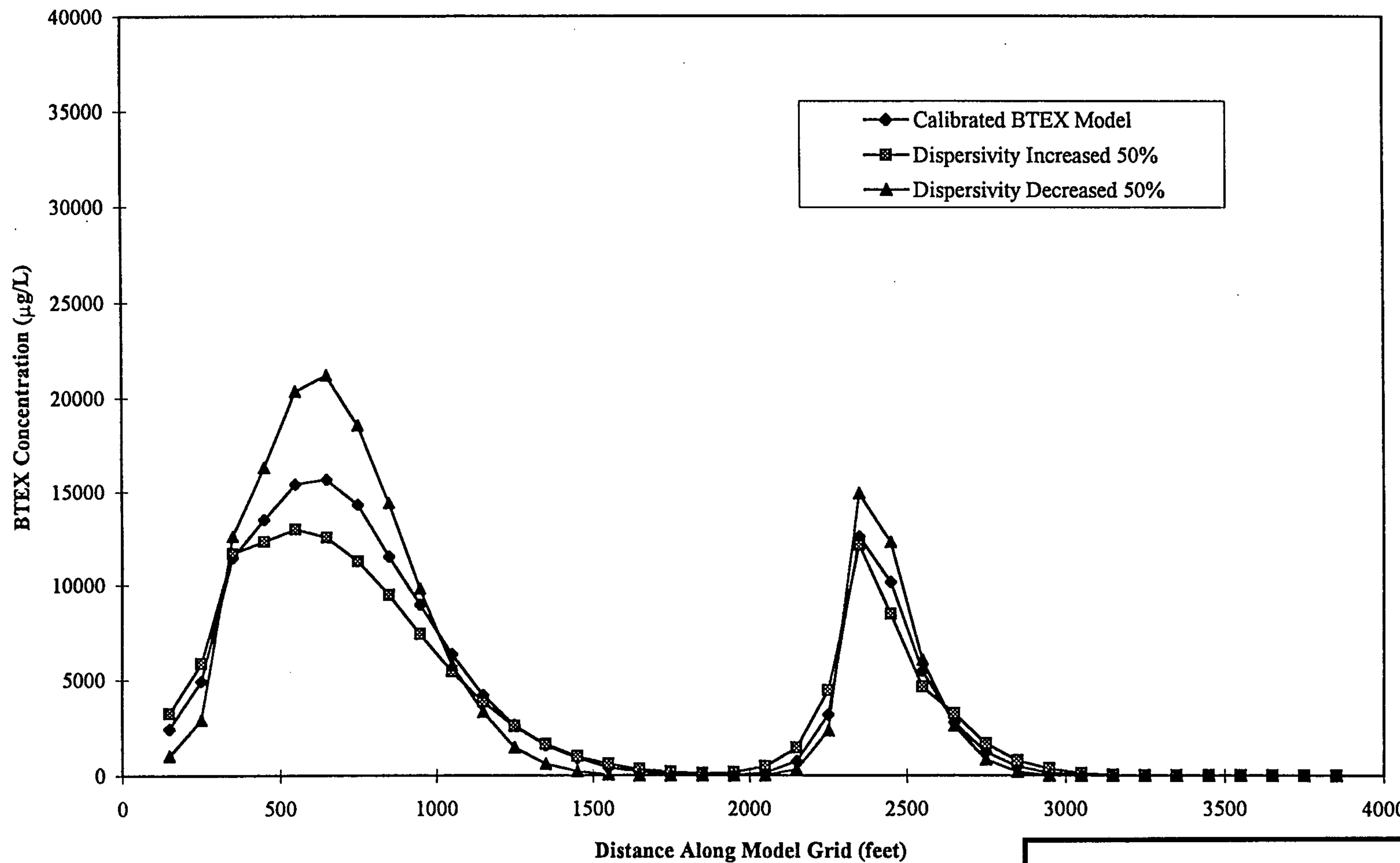

FIGURE 5.6

MODEL SENSITIVITY TO VARIATIONS IN DISPERSIVITY

Zone 1
Remediation by Natural Attenuation TS
Westover ARB, Massachusetts

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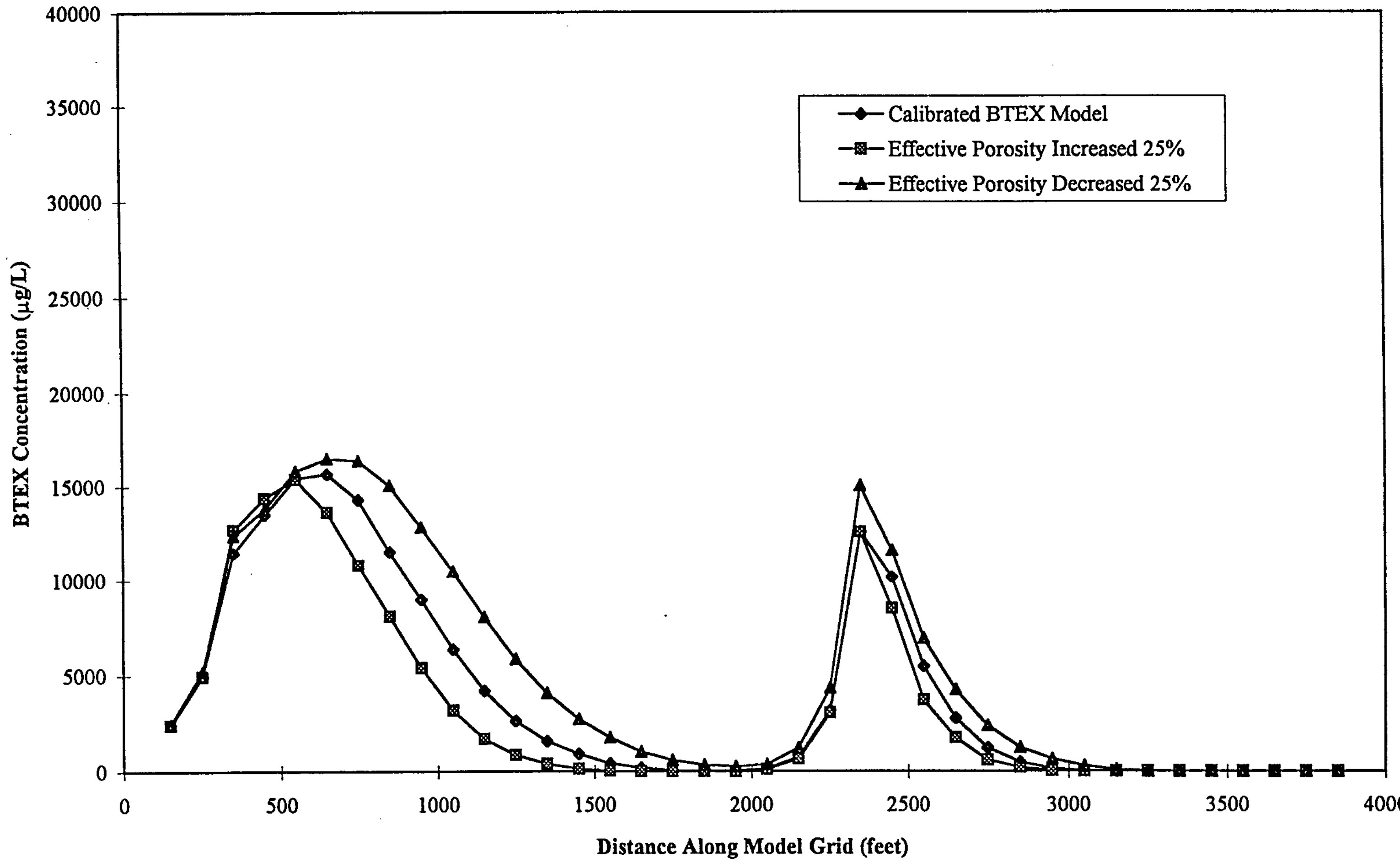

FIGURE 5.7

MODEL SENSITIVITY TO VARIATIONS IN EFFECTIVE POROSITY

Zone 1
Remediation by Natural Attenuation TS
Westover ARB, Massachusetts

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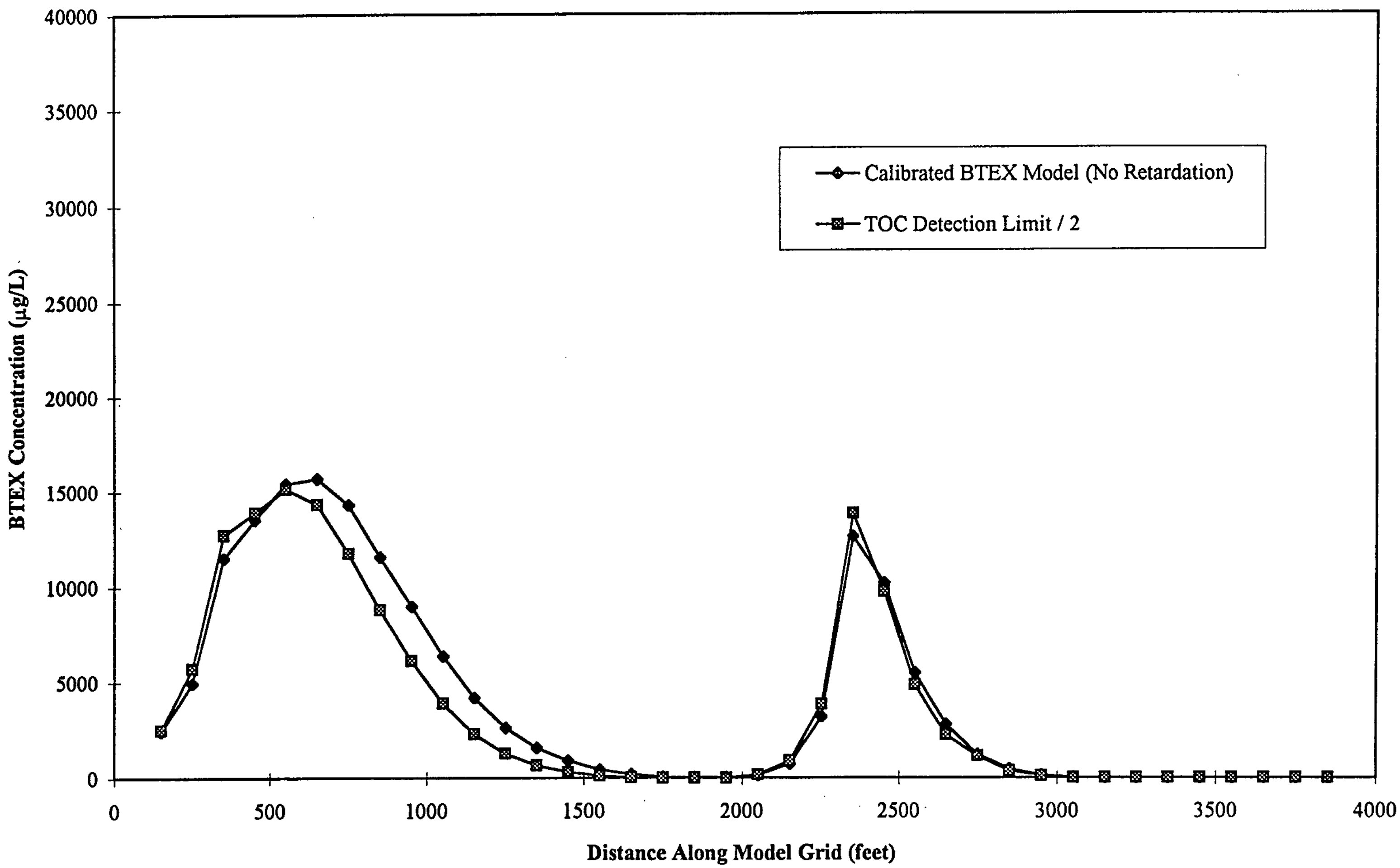

FIGURE 5.8

MODEL SENSITIVITY TO VARIATIONS IN DISTRIBUTION COEFFICIENT

Zone 1
Remediation by Natural Attenuation TS
Westover ARB, Massachusetts

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Denver, Colorado

decay and suggest that the coefficient of anaerobic decay calculated by the method of Buscheck and Alcantar (1995) is a reasonable value for the calibrated model.

The effects of varying dispersivity are illustrated by Figure 5.6. Both longitudinal and transverse dispersivity were varied for this analysis, as the ratio of the two values was kept constant at 0.01. Increasing the dispersivity by 50 percent resulted in a decrease in the maximum BTEX concentrations (by approximately 2,630 μg/L) without a noticeable change in downgradient extent. Decreasing the dispersivity by 50 percent produced a plume with higher BTEX concentrations (by approximately 5,600 μg/L) without a noticeable change in downgradient extent. This modeled plume extent appears to be moderately sensitive to dispersivity within the range of values evaluated for this analysis. However, within the source area the model is more sensitive to variations in dispersivity.

The effects of varying effective porosity are illustrated by Figure 5.7. Walton (1988) gives a range of 0.1 to 0.3 for the effective porosity of a sand. A comparison of the model using effective porosities that were increased and decreased by 25 percent (to 0.31 and 0.19, respectively) around the calibrated value of 0.25 shows a maximum BTEX concentration difference of approximately 750 μg/L at the source and does not change the plume extent. Therefore, the modeled plume is relatively insensitive to the range of reasonable effective porosity values.

The effects of varying the distribution coefficient are shown on Figure 5.8. The distribution coefficient was changed by increasing the TOC content to one-half of the detection limit which has a minor effect on the contaminant distribution. An increase in sorptive capacity caused a decrease of approximately 300 μg/L in the source area, producing a maximum BTEX concentration of 15,130 μg/L. The decrease in the maximum plume concentration resulted from a slowing of BTEX migration, which allowed for greater BTEX accumulation in the source area. A decrease in

concentrations resulted from an increased contact period of sorbed BTEX with electron acceptors flushing into the system.

The results of the sensitivity analyses suggest that the calibrated model parameters used for this report are appropriate. The calibrated model is very sensitive to the transmissivity and coefficient of anaerobic decay; moderately sensitive to dispersivity, and relatively insensitive to the effective porosity. Variations three times greater than the calibrated transmissivity value inaccurately simulate the dissolved plume and indicate that the model is unstable and mass balance errors resulting. Increasing the coefficient of anaerobic decay decreases the predicted maximum BTEX concentrations as well as the mass of BTEX in the system. Lowering the transmissivity or the coefficient of anaerobic decay has a reverse effect, and maximum concentrations of BTEX in the aquifer are increased. The model also appears to be relatively sensitive to the dispersivity because the low simulated decay rate causes more simulated plume mass to undergo dispersive loss. The model is insensitive to the porosity; however, variation of porosity contributed toward an appropriate plume configuration. Increasing the distribution coefficient by assuming a TOC value that is one-half of the detection limit, decreases the dissolved BTEX concentrations and suggests a slight sensitivity to low TOC values.

SECTION 6

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents the development and comparative analysis of three remedial alternatives for contaminated groundwater at Zone 1. The intent of this evaluation is to determine if RNA of groundwater is an appropriate and cost-effective remedial approach to consider when developing final remedial strategies for the study area, especially when combined with other remedial technologies.

Section 6.1 presents the criteria used to evaluate groundwater remedial alternatives. Section 6.2 discusses the development of remedial alternatives considered as part of this demonstration project. Section 6.3 provides a brief description of each of these remedial alternatives. Section 6.4 provides a more detailed analysis of the remedial alternatives using the defined remedial alternative evaluation criteria. The results of this evaluation process are summarized in Section 6.5.

6.1 REMEDIAL ALTERNATIVE EVALUATION CRITERIA

The evaluation criteria used to identify appropriate remedial alternatives for shallow groundwater contamination at the site were evaluated based on (1) long-term effectiveness and permanence, (2) technical and administrative implementability, and (3) relative cost. The following sections briefly describe the scope and purpose of each evaluation criterion. This report focuses on the potential use of RNA and source reduction technologies to reduce dissolved BTEX concentrations in the shallow groundwater below regulatory action levels.

6.1.1 Long-Term Effectiveness and Permanence

Each remedial technology or remedial alternative (which can be a combination of remedial approaches such as RNA and institutional controls) was analyzed to determine how effectively it will minimize groundwater plume expansion so that groundwater quality standards can be achieved at a downgradient POC. The future impact of each remedial alternative on the dissolved BTEX plume was simulated using the groundwater model discussed in Section 5. The expected technical effectiveness based on case histories from other sites with similar conditions also is evaluated. The ability to minimize potential impacts on surrounding facilities and operations is considered. Also, the ability of each remedial alternative to protect both current and potential future receptors from potential risks associated with potentially completed exposure pathways is qualitatively assessed. This evaluation criterion also included permanence and the ability to reduce contaminant mass, toxicity, and volume. Time for implementation and time until protection is achieved are described. Long-term reliability for providing continued protection, including an assessment of potential for failure of the technology and the potential threats resulting from such a failure, also is evaluated.

6.1.2 Implementability

The technical implementation of each remedial technology or remedial alternative was evaluated in terms of technical feasibility and availability. Potential shortcomings and difficulties in construction, operations, and monitoring are presented and weighed against perceived benefits. Requirements for any post-implementation site controls such as LTM and land use restrictions are described. Details on administrative feasibility in terms of the likelihood of public acceptance and the ability to obtain necessary approvals are discussed.

6.1.3 Cost

The total cost (adjusted to present worth) of each remedial alternative was estimated for relative comparison. An estimate of capital costs, and operating and post-implementation costs for site monitoring and controls is included. An annual adjustment factor of 7 percent was assumed in present worth calculations. The annual adjustment factor is the difference between the rate of inflation and the cost of money (USEPA, 1993).

6.2 FACTORS INFLUENCING ALTERNATIVES DEVELOPMENT

Several factors were considered during the identification and screening of remedial technologies for addressing shallow groundwater contamination at the site. Factors considered included the objectives of the AFCEE natural attenuation demonstration program; contaminant, groundwater, and soil properties; current and future land uses; and potential receptors and exposure pathways. The following section briefly describes each of these factors and how they were used to narrow the list of potentially applicable remedial technologies to the final remedial alternatives considered for the study area.

6.2.1 Program Objectives

The intent of the RNA demonstration program sponsored by AFCEE is to develop a systematic process for scientifically investigating and documenting natural subsurface attenuation processes that can be factored into overall site remediation plans. The objective of this program and the specific demonstration at Westover ARB is to provide solid evidence of RNA of dissolved fuel hydrocarbons so that this information can be used to develop an effective groundwater remediation strategy. The effectiveness of RNA to reduce chlorinated solvent concentrations in groundwater at the site is also evaluated. A secondary goal of this multi-site initiative is to provide a series of regional case studies that demonstrate that natural processes of contaminant degradation

can often reduce contaminant concentrations in groundwater to below acceptable cleanup standards before completion of potential receptor exposure pathways.

Because the objective of this program is to study natural processes in the saturated zone rather than all contaminated media (e.g., soil, soil gas, etc.), technologies have been evaluated based primarily on their potential impact on shallow groundwater and phreatic soils. Technologies that can reduce vadose zone contamination and partitioning of contaminants into groundwater also have been evaluated. Many of the source removal technologies evaluated in this section also will reduce soil and soil gas contamination, but it is important to emphasize that the remedial alternatives developed in this document are not intended to remediate all contaminated media. Additional program objectives set forth by AFCEE include cost effectiveness and minimization of waste. Technologies that may best meet these AFCEE criteria include institutional controls, soil vapor extraction, bioventing, bioslurping, passive drain collection, biosparging, and RNA. Under this program, slurry walls, sheet piling, carbon adsorption, and soil excavation with *ex situ* biological or chemical treatment typically are not considered attractive technologies.

6.2.2 Contaminant Properties

The site-related contaminants considered as part of this demonstration in the study area are the BTEX compounds. The primary source of contamination at Zone 1 is the release into the site soils of fuel hydrocarbons from a leaking fuel storage and distribution systems and surface spills. The removal of the 13 JP-4 USTs at site SS-19 in 1989 eliminated some contaminated soil. Soil bioventing in 1993 remediated the source soils at site SS-16 that were contaminated with JP-4 and JP-8. The mobile LNAPL observed at site SS-16 is believed to be the remaining primary source of contamination at the site SS-16 portion of Zone 1. Undifferentiated fuels and solvents from USTs at the WP-15 site are the source of the WP-15 contamination. The

physiochemical characteristics of JP-4 and the individual BTEX compounds will greatly influence the effectiveness and selection of a remedial technology.

JP-4 is classified as an LNAPL with a liquid density of approximately 0.75 g/cc at 20°C (Smith *et al.*, 1981). Because JP-4 is less dense than water, the LNAPL may become concentrated in the capillary fringe. Some of the individual fuel constituents sorb very well to the soil matrix, others dissolve quickly into percolating groundwater, and yet others may volatilize into soil vapor. This "weathering" process results in a variable distribution of individual fuel components in the soil, soil atmosphere, and groundwater with time and distance from the release [Biomedical and Environmental Information Analysis (BEIA), 1989]. Constituents in JP-4 range from slightly to highly soluble in water. Overall solubility is approximately 300 mg/L. JP-4 also can act as a primary substrate for biological metabolism. Simultaneous biodegradation of aliphatic, aromatic, and alicyclic hydrocarbons has been observed. In fact, mineralization rates of hydrocarbons in mixtures, such as JP-4, may be faster than mineralization of the individual constituents as a result of cometabolic pathways (Jamison *et al.*, 1975; Perry, 1984).

The BTEX compounds are generally volatile, highly soluble in water, and adsorb less strongly to soil than other hydrocarbons in a petroleum mixture. These characteristics allow the BTEX compounds to leach more rapidly from contaminated soil or LNAPL into groundwater, and to migrate as dissolved contamination (Lyman *et al.*, 1992). All of the BTEX compounds are highly susceptible to *in situ* degradation by both biotic and abiotic mechanisms.

Benzene is very volatile, with a vapor pressure of 76 millimeters of mercury (mm Hg) at 20°C and a Henry's Law Constant of approximately 0.0054 atmosphere-cubic meters per mole (atm-m^3/mol) at 25°C (Hine and Mookerjee, 1975; Jury *et al.*, 1984). The solubility of pure benzene in water at 20°C has been reported to be 1,780 mg/L

(Verschueren, 1983). Benzene is normally biodegraded to carbon dioxide, with catechol as a short-lived intermediate (Hopper, 1978; Ribbons and Eaton, 1992).

Toluene is also volatile, with a vapor pressure of 22 mm Hg at 20°C and a Henry's Law Constant of about 0.0067 atm-m^3/mol at 25°C (Pankow and Rosen, 1988; Hine and Mookerjee, 1975). Toluene sorbs more readily to soil media relative to benzene, but still is very mobile. The solubility of pure toluene in water at 20°C is approximately 515 mg/L at 20°C (Verschueren, 1983). Toluene has been shown to degrade to pyruvate, caetaldehyde, and completely to carbon dioxide via the intermediate catechol (Hopper, 1978; Wilson *et al.*, 1986; Ribbons and Eaton, 1992).

Ethylbenzene has a vapor pressure of 7 mm Hg at 20°C and a Henry's Law Constant of 0.0066 atm-m^3/mol (Pankow and Rosen, 1988; Valsaraj, 1988). Ethylbenzene sorbs more strongly to soils than benzene and toluene (Kenaga and Goring, 1980; Means *et al.*, 1980; Hassett *et al.*, 1983; Fetter, 1993). Pure ethylbenzene is also less soluble than benzene and toluene in water at 152 mg/L at 20°C (Verschueren, 1983; Miller *et al.*, 1985). Ethylbenzene ultimately degrades to carbon dioxide via its intermediate 3-ethylcatechol (Hopper, 1978; Ribbons and Eaton, 1992).

The three isomers of xylene have vapor pressures ranging from 7 to 9 mm Hg at 20°C and Henry's Law Constants of between 0.005 and 0.007 atm-m^3/mol at 25°C (Mackay and Wolkoff, 1973; Hine and Mookerjee, 1975; Pankow and Rosen, 1988). A compilation of literature values for sorption coefficients suggests that xylenes sorb to soil with approximately the same affinity as ethylbenzene (Wiedemeier *et al.*, 1995). Pure xylenes have water solubilities of 152 to 160 mg/L at 20°C (Bohon and Claussen, 1951; Mackay and Shiu, 1981; Isnard and Lambert, 1988). Xylenes can degrade to carbon dioxide via pyruvate carbonyl intermediates (Hopper, 1978; Ribbons and Eaton, 1992).

On the basis of these physiochemical characteristics, RNA, mobile LNAPL recovery, biosparging, and groundwater extraction and treatment could all be effective options for collecting, destroying, and/or treating BTEX at Zone 1. Active soil remediation was not considered feasible because of the low levels of soil contamination remaining in site soils (Section 4.1). Some of the options for groundwater remediation are considered less desirable after considering site-specific conditions (Section 6.2.3).

6.2.3 Site-Specific Conditions

Three general categories of site-specific characteristics were considered when identifying remedial approaches for comparative evaluation as part of this demonstration. The first category was physical characteristics such as groundwater depth, hydraulic conductivity, gradient, flow direction, and soil type. The second category was the site geochemistry, or how the site contaminants are interacting with electron acceptors, microorganisms, and other site contaminants. Both of these categories influence the types of remedial technologies most appropriate for the site. The third category involved assumptions about future land use and potential receptor exposure pathways. Each of these site-specific characteristics has influenced the development of remedial alternatives included in the comparative evaluation.

6.2.3.1 Physical Characteristics

Geology and hydrogeology have a profound effect on the transport of contaminants and the effectiveness and scope of required remedial technologies at a given site. Hydraulic conductivity is perhaps the most important aquifer parameter governing groundwater flow and contaminant transport in the subsurface. The velocity of the groundwater and dissolved contamination is directly related to the hydraulic conductivity of the saturated zone. The estimated average hydraulic conductivity at Zone 1 is 0.013 ft/min (18.2 ft/day) (Section 3.3.2.2), which is characteristic of sand (Freeze and Cherry, 1979). On the basis of this value, the advective groundwater velocity is estimated at 106 ft/yr.

Although high hydraulic conductivity can result in plume expansion and migration, this same characteristic will also enhance the effectiveness of some remedial technologies, such as groundwater extraction, biosparging, and RNA. The rapid movement of contaminants within the subsurface away from the source increases the effectiveness of biodegradation processes by distributing the contaminant mass into areas enriched with electron acceptors. A groundwater extraction system in an area of high hydraulic conductivity would be more effective because fewer wells would be required to envelope the desired capture zone and sustain a sufficient flow rate. The effectiveness of biosparging on dissolved BTEX contamination also is increased in high-conductivity aquifers because the lower entry pressures required to introduce oxygen into the groundwater would reduce short-circuiting within the well borehole.

6.2.3.2 Geochemical Characteristics

To satisfy the requirements of indigenous microbial activity and RNA, the aquifer also must provide an adequate and available carbon or energy source (e.g., fuel hydrocarbon contamination), electron acceptors, essential nutrients, and proper ranges of pH, temperature, and ORP. Data collected as part of the field work phase of this demonstration project and described in Sections 3 and 4 of this TS indicate that this site is characterized by adequate and available carbon/energy sources and electron acceptors to support measurable biodegradation of fuel hydrocarbon and chlorinated solvent contamination by indigenous microorganisms. DO, nitrate, ferric iron, sulfate, and carbon dioxide represent sources of significant electron acceptor capacity for the biodegradation of BTEX and the lesser-chlorinated solvent compounds at Zone 1 (Table 4.6). The pH conditions at some locations are less than optimal, but overall are adequate to support biological activity. ORPs ranged from 313 to -207.5 mV in September 1996 (Figure 4.8), and suggest a groundwater environment that is both oxidizing and reducing. The electron acceptor distribution, reaction byproduct concentrations, and ORPs at the site suggest that aerobic biodegradation, nitrate

reduction, ferric iron reduction, sulfate reduction, and methanogenesis (consistent with observed geochemical indicator trends discussed in Section 4), would reduce fuel contamination in groundwater despite less-than-optimal pH conditions throughout portions of the site. The site biological activity has contributed to geochemistry that is conductive to degradation through reductive dechlorination of CAHs in vicinity of WP-15. Furthermore, the less-reducing downgradient groundwater conditions are favorable for aerobic degradation of the less-chlorinated compounds (i.e., DCE and vinyl chloride).

Microbe addition was not considered a viable remedial approach for this site on the basis of observed geochemical trends that suggest that significant microbial activity is occurring. Fuel-hydrocarbon-degrading microorganisms are ubiquitous in the subsurface, and as many as 28 hydrocarbon-degrading isolates (bacteria and fungi) have been discovered in different soil environments (Davies and Westlake, 1979; Jones and Eddington, 1968). Indigenous microorganisms have a distinct advantage over microorganisms injected into the subsurface to enhance biodegradation because indigenous microorganisms are well adapted to the physical and chemical conditions of the subsurface in which they reside (Goldstein *et al.*, 1985).

6.2.3.3 Potential Receptor Exposure Pathways and Routes

A pathways analysis identifies the potential human and ecological receptors that could come into contact with site-related contamination, and the pathways through which these receptors might be exposed. To have a completed exposure pathway, there must be a source of contamination, a potential mechanism(s) of release, a pathway for transport to an exposure point, an exposure point, and a receptor. If any of these elements do not exist, the exposure pathway is considered incomplete, and receptors will not come into contact with site-related contamination. Evaluation of the potential long-term effectiveness of any remedial technology or remedial alternative as part of this demonstration project includes determining the potential for pathway completion.

If a completed exposure pathway exists (e.g., surface water contact), potential long-term remedial options may still be sufficient to maintain exposure concentrations below regulatory action levels. Establishing site-specific, risk-based cleanup levels is beyond the scope of this TS.

Assumptions about current and future land uses at a site form the basis for identifying potential receptors, potential exposure points, reasonable exposure scenarios, and appropriate remediation goals. USEPA (1991) advises that the land use associated with the highest (most conservative) potential level of exposure and risk that can reasonably be expected to occur should be used to guide the identification of potential exposure pathways and to determine the level to which a site must be remediated.

An exposure point is a location at which any potentially exposed receptor could come into contact with site-related contamination. On-Base contaminated media will be considered possible human receptor exposure points only for those Base personnel who currently or may in the future have access to Zone 1 and for potential off-Base receptors who may contact contaminated groundwater (or surface water) that may migrate offsite. Potential onsite exposure points include breathing zone air within the perimeter of the property and subsurface soils and groundwater underlying and downgradient from the site. Potential offsite exposure points include air and groundwater at the perimeter of the base downgradient from Zone 1, and surface water at a hypothetical discharge point to Cooley Brook. Because this report focuses on groundwater characterization, only those pathways that rely on contaminant migration in groundwater are considered further.

Zone 1 is surrounded by Base operations buildings, storage yards, and intervening relatively undeveloped areas for at least 2,000 feet east of the site. The SS-19 portion of Zone 1 is used for aircraft parking, fueling, and maintenance and is in a secured

area. Cooley Brook is the nearest possible groundwater receptor exposure point located approximately 2,000 feet east of the site, at the base boundary. On-site environmental receptors were not identified in the Phase II RI investigation (OB&G, 1997). Off-site environmental receptors include aquatic, avian, and terrestrial biota that have access to Cooley Brook. However, observed BTEX concentrations (Figures 4.2) and modeling results presented in Section 6.4.1.1 suggest that contaminant concentrations emanating from Zone 1 are attenuated before reaching the creek.

The Massachusetts Contingency Plan (MCP) classifies potential human receptors according to the frequency and intensity of potential exposures to soil and groundwater. Groundwater at Zone 1 is not used for potable uses, and the aquifer in this area is not classified as high yield by the Massachusetts Department of Environmental Protection (MADEP) (OB&G, 1997). On the basis of this classification, there are no potential receptors exposed to groundwater via potable water wells on site or in the surrounding area. Furthermore, access to Zone 1 and the surrounding area is restricted and on-site adult workers are the only current potential receptor. The Base is scheduled to remain as an active reserve Base, and the future potential receptors are not expected to change.

Probable exposure routes are dependent upon which receptors come into contact with what contaminated media. Based on a review of available data, the following groundwater exposure routes are considered viable for current and potential future human receptors: (1) incidental ingestion of contaminated groundwater, surface water, and sediment; and (2) incidental dermal contact with contaminated groundwater, surface water, and sediment.

6.2.3.4 Remediation Goals for Shallow Groundwater

In 1988, MADEP promulgated regulations as Title 310 of the Commonwealth of Massachusetts Regulations (310 CMR) 40.0000 to implement the MCP, pursuant to Massachusetts General Law c.21E, s.3 and s. 6. The MCP is intended to provide for

the protection of health, safety, public welfare, and the environment by establishing requirements and procedures for preventing/controlling chemical releases, notification, assessments, remedial alternatives evaluations, and public involvement. The MCP is intended to comply with and complement the National Contingency Plan (NCP) promulgated by the USEPA under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA).

Groundwater categories for compliance with the MCP are defined in 310 CMR 40.0932(4). Groundwater is classified as GW-1 if it is an existing or potential source of potable water. A GW-2 category is established for contaminated groundwater located within 30 feet of an occupied building that may act as a source of hazardous vapor migration the structure. A GW-3 classification is placed on groundwater that discharges to surface water. Groundwater underlying and downgradient from Zone 1 has been classified as Groundwater Category GW-2 (OB&G, 1997). Downgradient from the site in the vicinity of Cooley Brook, the groundwater is classified as Category GW-3 (OB&G, 1997). The groundwater category GW-2 is the more stringent category applicable to Zone 1 and the downgradient area near Cooley Brook. Therefore, GW-2 standards for the BTEX compounds were used to estimate the time required for groundwater remediation. GW-2 standards for the BTEX compounds are presented in Table 6.1. Viable remedial alternatives must be able to achieve GW-2 or other risk-based standards that are protective of human health and the environment.

Because it is unlikely that groundwater from Zone 1 would be ingested by humans as a result of Base security, current land use, and the Base water supply, the state GW-2 standard of 2,000 μg/L for benzene will be used to evaluate the effectiveness, Implementability, and cost of remedial alternatives in this TS. It is possible that use of the benzene MCP standard may be overly conservative with respect to the risk to human health; however, a risk-based assessment would be required along with the

conservative groundwater model predictions. If groundwater concentrations protective of human health and the environment can be negotiated with the state on the basis of site-specific exposure scenarios, the time and cost of the proposed remedial alternative (Section 6.5) could potentially be decreased.

TABLE 6.1
GROUNDWATER QUALITY STANDARDS
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Compound	MCP GW-2 Groundwater Standard (μg/L)[a/]
Benzene	2,000
Toluene	6,000
Ethylbenzene	30,000
Xylenes	6,000

[a/] Source: MADEP, 1995.

For this TS, the primary remedial objective for shallow groundwater is to reduce contaminant concentrations in groundwater below state regulatory criteria at a downgradient POC. To accomplish this, remedial alternatives focus on removing or reducing the mobile LNAPL source within the source area at Zone 1 while relying on RNA to limit migration of the dissolved contaminant plume. Active source removal such as excavation and/or engineered *in situ* soil treatment was not considered because soil contamination has not been identified as a sizable continuing source of dissolved contamination at Zone 1.

In summary, available data suggest that completed exposure pathways involving human and ecological receptors exposed to contaminated groundwater or surface water do not exist under current conditions. As a part of airfield operations, the Zone 1 facility is designated as a secured area. Thus, the institutional controls associated with

the airfield operations are likely to limit any future intrusive activity at the site. The required period of any groundwater and soil institutional controls associated with the selected remedial technology is likely to expire before any anticipated future land use changes take place.

6.2.4 Summary of Remedial Option Screening

Several remedial options have been identified and screened for use in treating the shallow groundwater at the site. Table 6.2 identifies the initial remedial technologies and approaches considered as part of this demonstration and those retained for detailed comparative analysis. Screening was conducted systematically by considering the program objectives of the AFCEE RNA demonstration, physiochemical properties of organic site contaminants, and other site-specific characteristics such as hydrogeology, geochemistry, land use assumptions, potential receptor exposure pathways, and appropriate remediation goals. All of these factors will influence the technical effectiveness, implementation, and relative cost of technologies for remediating shallow groundwater underlying and migrating from the site. The remedial options retained for development of remedial alternatives and comparative analysis include institutional controls, natural attenuation, LTM, mobile LNAPL recovery, and groundwater extraction with *ex-situ* treatment.

6.3 BRIEF DESCRIPTION OF REMEDIAL ALTERNATIVES

This section describes how remedial technologies retained from the screening process were combined into three remedial alternatives for the study area. Sufficient information on each remedial alternative is provided to facilitate a comparative analysis of effectiveness, implementability, and cost in Section 6.4.

TABLE 6.2
INITIAL TECHNICAL IMPLEMENTABILITY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER REMEDIATION
ZONE 1 REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

General Response Action	Technology Type	Process Option	Technical Implementability	Retain
Long-Term Monitoring	Periodic Groundwater Monitoring	Confirmation Wells	Many existing wells are available to confirm the progress of remediation.	Yes
		Point-of-Compliance Wells	Sufficient distance exists between the plume and point-of-compliance to locate several wells.	Yes
Institutional Controls	Groundwater Use Control	Land Use Control/Regulate Well Permits	Plume area is currently within the Base boundary and land-use and groundwater use are under base jurisdiction.	Yes
		Seal/Abandon Existing Wells	No production wells are known to exist in the existing or predicted plume area.	No
		Point-of-Use Treatment	No groundwater is extracted from the plume area for any use.	No
	Public Education	Meetings/ Newsletters	Base public relations and environmental management offices have many information avenues to inform workers and residents.	Yes
Containment of Plume	Hydraulic Controls	Passive Drain Collection	No likely receptors downgradient of site. Installation disruptive to base operations. Prohibitive due to groundwater depth.	No
		Minimum Pumping/Gradient Control	Vertical pumping wells could be located along the leading edge of plume to intercept and halt the advance of the plume. Required pumping rates would be excessive, increasing treatment costs. Plume not predicted to reach likely receptors downgradient of site.	No
	Physical Controls	Slurry Walls/Grout Curtains	Requires significant disruption of Base operations. Limited effectiveness.	No
		Sheet Piling	Requires significant disruption of Base operations. Limited effectiveness.	No
	Reactive/Semi-Permeable Barriers	Biologically Active Zones	Natural biodegradation of BTEX compounds can be stimulated by allowing contaminated groundwater to flow through an aquifer zone that has enhanced oxygen and nutrient conditions. Not practical for excessive contaminant concentrations.	No

TABLE 6.2 (Continued)
INITIAL TECHNICAL IMPLEMENTABILITY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER REMEDIATION
ZONE 1 REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

General Response Action	Technology Type	Process Option	Technical Implementability	Retain
In Situ Treatment	Biological	Oxygen and/or Nutrient Enhanced Biodegradation (Biosparging)	Differs from biologically active zone in that oxygen and/or nutrients are injected in source area and allowed to migrate downgradient. This method can more rapidly reduce higher BTEX concentrations in and immediately downgradient of the source area. Not proven to be any more effective than natural attenuation.	No
	Chemical/ Physical	Natural Attenuation	A combination of natural biological, chemical, and physical removal mechanisms which occur to varying degrees on every site. Groundwater sampling at Zone 1 indicates that this is a major, ongoing remediation process.	Yes
		Air Sparging (Volatilization)	Injection of air into contaminated aquifer creating a mass transfer of BTEX into air bubbles and into vadose zone. Limited radius of influence, short-circuiting, and diffuse air emissions are common problems. Oxygen addition could prohibit reductive dechlorination of CAHs in anerobic plume core.	No
Groundwater Extraction		Vertical Pumping Wells	Entire groundwater plume is pumped by installing numerous wells with submersible pumps. High cost and major disruption to area. Relatively high hydraulic conductivity would make groundwater recovery effective provided mobile LNAPL is remediated.	No
		Downgradient Horizontal Drains	See Passive Drain Collection.	No
Aboveground Groundwater Treatment	Biological	Bioreactors	High flow rates require excessive retention times and large reactors. BTEX is often volatilized in these systems.	No
	Chemical/ Physical	Air Stripping	Cost-effective technology for removing varying concentrations of BTEX at higher flow rates. Permitting for air emissions may be required. Not effective as a final remediation measure unless the residual LNAPL is remediated.	Yes
		Activated Carbon	Cost prohibitive for more concentrated BTEX. Creates a secondary waste (carbon) stream. Not effective on some chlorinated solvents.	No
		UV/Ozone Reactors	High flow rates require excessive retention times and large, expensive reactors.	No

TABLE 6.2 (Continued)
INITIAL TECHNICAL IMPLEMENTABILITY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER REMEDIATION
ZONE 1 REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

General Response Action	Technology Type	Process Option	Technical Implementability	Retain
Aboveground Treatment	Direct Discharge to Industrial Waste Water Treatment Plant (IWWTP)	IWWTP	Viable option when an IWWTP is available and capable of handling contaminant and hydraulic loading. Plume dimensions and sandy conditions would require very high hydraulic loading in order to control the plume.	No
Treated Groundwater Disposal	Discharge to IWWTP or Sanitary Sewer	IWWTP	Viable option when access to industrial sewer exists and hydraulic loading is acceptable.	Yes
		Sanitary Sewer	Viable option when access to sanitary sewer exists and hydraulic loading is acceptable. Same as above.	No
	Treated Groundwater Reinjection	Vertical Injection Wells	Not recommended due to clogging and high maintenance.	No
		Injection Trenches	Less clogging than wells, but large trenches are required and can be subject to injection well permitting.	No
	Discharge to Surface Waters	Storm Drains	Viable option but generally requires NPDES or other discharge permit. Groundwater extraction is unlikely.	No
Source Removal/Soil Remediation	Mobile LNAPL Recovery	Dual-Pump Systems	Best suited for sites with >1 foot mobile LNAPL where aboveground groundwater treatment already exists	No
		Skimmer Pumps/Passive Bailers/Wicks	Best suited for sites with <1 foot mobile LNAPL where groundwater pumping is undesirable.	Yes
		Total Fluids Pumping	Best suited for sites with thin saturated zones where excessive groundwater will not be pumped.	No
		Bioslurping	Combined vapor extraction, bioventing, and mobile LNAPL recovery system has been operated at some sites with limited success. Minimal product at site.	No
		Hand Bailing	The limited quantity of mobile LNAPL at the site makes this method ineffective.	No
	Excavation/ Treatment	Biological Landfarming	Deep excavation is not desirable at this site due to surface structures and ongoing base operations.	No

TABLE 6.2 (Concluded)
INITIAL TECHNICAL IMPLEMENTABILITY SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER REMEDIATION
ZONE 1 REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

General Response Action	Technology Type	Process Option	Technical Implementability	Retain
Source Removal/Soil Remediation (cont'd)	Excavation/ Treatment (cont'd)	Thermal Desorption	Deep excavation is not desirable at this site due to surface structures and ongoing base operations.	No
	In Situ	Bioventing	Air injection to stimulate biodegradation of fuel residuals. Limited fuel residuals in soil suggest bioventing would not be economical.	No
		Soil Vapor Extraction	Limited fuel residuals in soils at Zone 1 would make SVE uneconomical because of supplemental fuel cost. Also, often requires expensive off-gas treatment.	No

6.3.1 Alternative 1 - RNA and Institutional Controls with Long-Term Groundwater Monitoring

RNA is achieved when natural attenuation mechanisms bring about a reduction in the total mass of a contaminant in the soil or dissolved in groundwater. RNA results from the integration of several subsurface attenuation mechanisms that are classified as either destructive or nondestructive. Destructive attenuation mechanisms include biodegradation, abiotic oxidation, and hydrolysis. Nondestructive attenuation mechanisms include sorption, dilution (caused by dispersion and infiltration), and volatilization. In some cases, RNA will reduce dissolved contaminant concentrations below numerical concentration goals intended to be protective of human health and the environment (e.g., the MCP GW-2 standards). As indicated by the evidence of RNA described in Section 4, these processes are occurring in the vicinity of Zone 1 and will continue to reduce contaminant mass in the plume area.

Implementation of Alternative 1 would require the use of institutional controls such as land use restrictions and LTM. Land use restrictions may include placing long-term restrictions on soil excavation within the source area and long-term restrictions on groundwater well installations within and downgradient from the plume area. The intent of these restrictions would be to reduce potential receptor exposure to contaminants by legally restricting activities within areas affected by site-related contamination.

Long-term monitoring is the technical mechanism used to ensure that the progress of natural attenuation processes and to ensure that remedial objectives are being met. LTM would be performed at a regular frequency with samples collected from a set of wells including upgradient, source area, plume extent, and POC monitoring wells. The site- and alternative-specific LTM strategy is provided in Section 7. To prevent an exposure at Cooley Brook or any downgradient receptor exposure point, three POC well clusters should be installed downgradient from the current plume front, and

additional LTM well should be installed between the current observed plume front and the POC. In addition, 24 LTM wells within and upgradient from the existing contaminant plume would be used to monitor the effectiveness of RNA within the surficial aquifer. Additional details (including monitoring locations) for LTM of groundwater are provided in Section 7.2. Detection of benzene in excess of 2,000 μg/L at the furthest downgradient LTM well, or at a POC well, would require additional evaluation to assess BTEX migration, and to determine the probable extent of migration, and to determine if additional corrective action is necessary. Regulatory standards for other detected fuel compounds are much higher than the benzene GW-2 standard (Table 6.1); therefore, it is unlikely that these standards would be exceeded sooner than would the benzene standard. In either case, land use restrictions would require reevaluation.

Public education on the selected alternative would be developed to inform Base personnel and residents of the scientific principles underlying source reduction and RNA. This education could be accomplished through public meetings, presentations, press releases, and posting of signs where appropriate. Periodic site reviews also could be conducted every year using data collected from the long-term groundwater and surface water monitoring program. The purpose of these periodic reviews would be to evaluate the extent of contamination, assess contaminant migration and attenuation through time, document the effectiveness of source removal and/or institutional controls at the site, and reevaluate the need for additional remedial actions at the site.

6.3.2 Alternative 2 - Mobile LNAPL Recovery, RNA, and Institutional Controls with Long-Term Groundwater Monitoring

This alternative is identical to Alternative 1 except that passive mobile LNAPL recovery would be used to recover the remaining mobile LNAPL source at site SS-16. An active product recovery system would not be feasible because the of low volume of mobile LNAPL present at the site. On the basis of Parsons ES experience in the

application of LNAPL recovery systems, one passive LNAPL skimmer installed in monitoring well ECS-26 should be sufficient to remediate the LNAPL plume. The passive skimmer consists of four primary components: a floating intake head, a guide rod and flexible tube, a well-centering disk, and a clean product canister. A floating intake head adjusts for water table fluctuation. Hydrocarbons enter the skimmer through the floating intake's outer debris screen, and then flow through an inner oileophilic, hydrophobic screen, down through a flexible, yellow tube, and into the see-through canister. To empty the skimmer, it is pulled to the surface, and the canister is drained using the valve at its base. The skimmer is returned to the well until next checked at its predetermined maintenance interval.

6.3.3 Alternative 3 - Groundwater Extraction, Mobile LNAPL Recovery, RNA, and Institutional Controls with Long-Term Groundwater Monitoring

This alternative is identical to Alternative 2, with the addition of groundwater extraction in the SS-19 source area and downgradient from the SS-16 source area to accelerate the removal of dissolved groundwater contamination. An air stripper located near each of the target source areas would be used to remove VOCs from the extracted groundwater. By reducing the mobile LNAPL source and the quantity of dissolved BTEX within and downgradient from the source areas, groundwater extraction would reduce the predicted length of time required for RNA to complete groundwater remediation. Prior to conducting groundwater extraction, a site characterization study should be performed to better delineate the extent of shallow aquifer and to collect additional data on aquifer characteristics. As with Alternative 1, institutional controls and LTM would be required. LTM wells would be the same as described for Alternative 1.

6.4 EVALUATION OF ALTERNATIVES

This section provides a comparative analysis of each of the remedial alternatives based on the effectiveness, implementability, and cost criteria. A summary of this evaluation is presented in Section 6.5.

To predict fate and transport of dissolved BTEX compounds at Zone 1, three Bioplume II simulations (RNA, Passive, and Pump) were run under different sets of conditions. Input and output files for each simulation are presented in Appendix D. Each model is evaluated with respect to maximum total BTEX concentrations and the extent of the 2,000-μg/L total BTEX isopleth. The 2,000-μg/L isopleth was selected on the basis of the MCP GW-2 contaminant level for benzene (2,000 μg/L). Because of Bioplume II limitations, the model simulations assume the total BTEX concentration consists entirely benzene. Site data indicate that benzene is a relatively minor constituent in the dissolved BTEX fraction at Zone 1 (Table 4.3). Therefore, the selection of the 2,000-μg/L isopleth likely overestimates the actual future benzene concentrations because current benzene concentrations are less than 25 percent of the total dissolved BTEX mass at the site.

6.4.1 Alternative 1 - RNA and Institutional Controls with Long-Term Groundwater Monitoring

6.4.1.1 Effectiveness

Alternative 1 is based on the effectiveness of natural processes that minimize contaminant migration and reduce contaminant mass over time, and the effectiveness of institutional controls. Model RNA was used to simulate the migration and biodegradation of the BTEX plume assuming that only natural physical weathering decreased BTEX loading in the source areas. Physical weathering included BTEX dissolution from mobile and residual contamination in saturated soils directly into groundwater and from residual contamination in the vadose zone into infiltrating precipitation. This model also assumes that the contaminant source is reduced slightly

by volatilization of BTEX in the vadose zone and LNAPL plume or by chemical or biological degradation of residual product sorbed to in site soils.

In order to simulate the anticipated decrease in the source size and composition, model RNA utilized 68 pumping periods beginning in 1965. The first 23 pumping periods duplicate the calibrated model conditions. Each of the following pumping periods has a duration of 1 year and assumes a BTEX injection rate lower than the previous period as a result of weathering. The reduced BTEX injection rates represent a geometric source reduction rate of approximately 5 percent per year. Assuming that future releases do not occur at the site, the annual source reduction rate of 5 percent is potentially a conservative value for natural source weathering.

This model predicts decreasing maximum plume concentrations, with the plume extent increasing steadily through 2010. Figure 6.1 shows the modeled plume for 2001 (5 years of simulated weathering), 2010 (13 years of simulated weathering), and 2019 (22 years of simulated weathering). From 1997 to 2010, the modeled downgradient extent of the 5-μg/L BTEX isopleth increases to a steady-state position approximately 500 feet downgradient from the observed September 1996 position and approximately 600 feet upgradient from Cooley Brook, remaining at approximately this location for the duration of the simulation. In year 2001, the maximum BTEX concentration is predicted to decrease by 25 percent, from approximately 15,600 μg/L to 11,550 μg/L. (Figure 6.1). After 13 years of weathering (year 2010), total BTEX concentrations further decrease to a maximum of 5,690 μg/L, or 36 percent of the calibrated maximum concentration. Along with a decreasing maximum concentration, the entire area encompassed by the 2,000-μg/L contour has receded to within 500 feet of both the SS-16 and SS-19 source areas. After 22 years of natural weathering, the model estimates a maximum BTEX concentration of 2,335 μg/L (Figure 6.1), with maximum

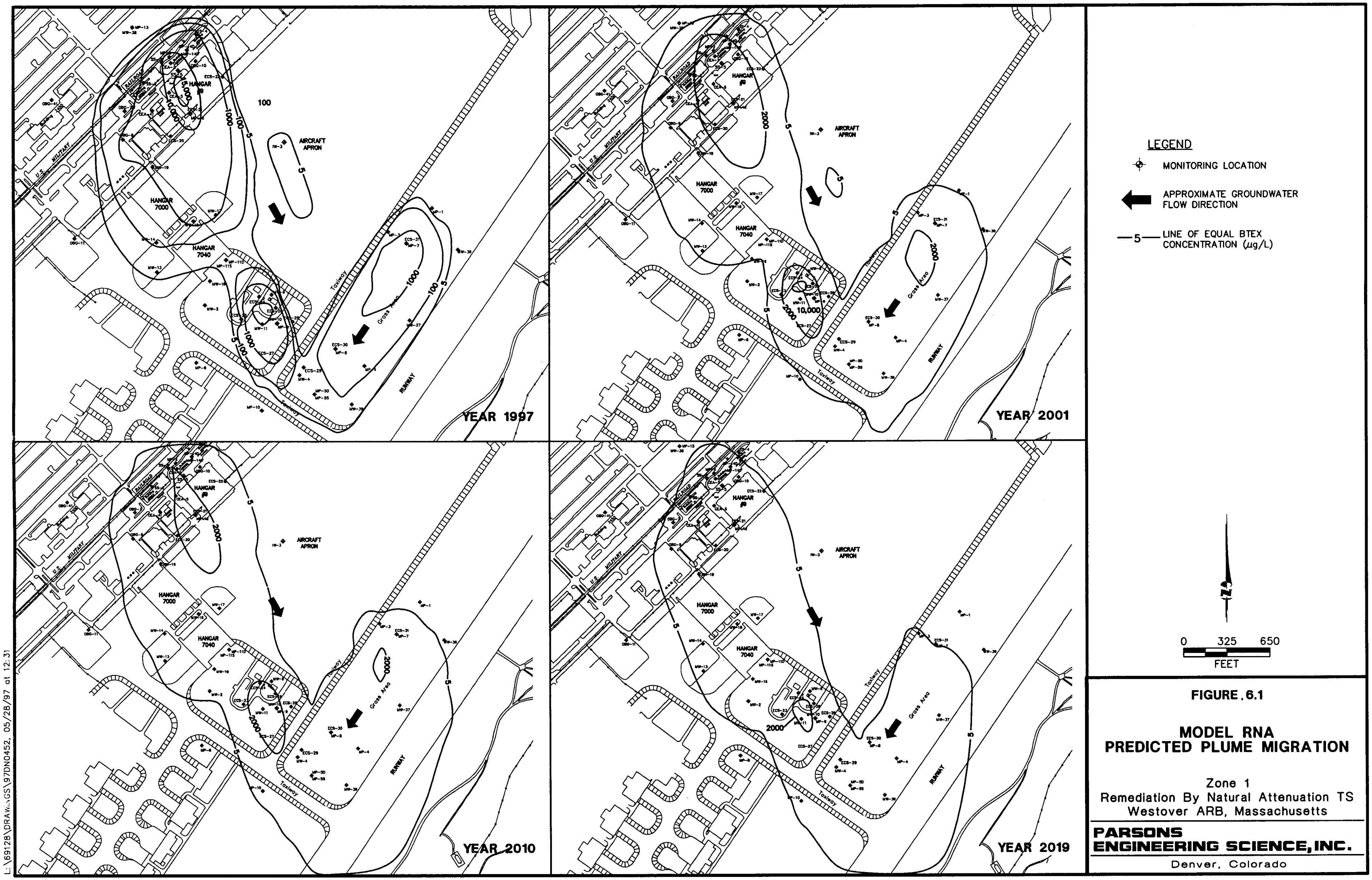

FIGURE 6.1

MODEL RNA
PREDICTED PLUME MIGRATION

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado

L:\69128\DRAWINGS\97DN0452, 05/28/97 at 12:31

BTEX concentrations in subsequent years below the GW-2 benzene standard (2,000 µg/L).

These results suggest that the maximum observed BTEX concentrations will steadily decrease over the next 22 years without any further engineered removal (i.e., assuming only physical weathering is taking place in the source areas). The results also suggest that RNA is sufficient to limit migration of the dissolved BTEX plume. BTEX (and specifically benzene) concentrations should never exceed state-specified levels at Cooley Brook, the downgradient POC, throughout the estimated 22-year remediation time period. Furthermore, the results suggest that no site BTEX contamination should reach the creek. While this alternative would not cease to be protective if the BTEX plume were intercepted by the POC wells, such an instance would indicate that site conditions should be reevaluated.

The effectiveness of this remedial alternative requires that future intrusive site activities or construction activities within the source area be conducted only by properly protected site workers. Reasonable land use assumptions for the plume area indicate that exposure is unlikely unless excavation or drilling activities bring saturated soil to the surface. Long-term land use restrictions would be required to ensure that shallow groundwater is not pumped or removed for potable use within a radius of approximately 500 feet from the margins of the existing BTEX plume. Existing health and safety plans should be enforced to reduce worker exposures during additional excavation or installing and monitoring additional wells.

Compliance with program goals is one component of the long-term effectiveness evaluation criterion. Alternative 1 would satisfy program objectives designed to promote RNA as a component of site remediation and to scientifically document natural processes; This alternative also satisfies program goals for cost effectiveness and waste minimization.

Apart from the administrative concerns associated with the enforcement of long-term land use restrictions and long-term groundwater monitoring programs, this remedial alternative should provide reliable, continuous protection. It is assumed that dissolved benzene concentrations will exceed the state criterion throughout the plume for approximately 23 years under Alternative 1. Furthermore, it is assumed for cost comparison that sampling will be performed annually for the first 5 years, and every second year for 17 years to demonstrate that RNA will be protective at the POC while uniformly reducing all dissolved BTEX compounds to levels below regulatory criteria.

6.4.1.2 Implementability

Alternative 1 is not technically difficult to implement. Installation of any additional LTM wells and monitoring of groundwater and surface water are standard procedures. Long-term management efforts would be required to ensure proper sampling procedures are followed. Periodic site reviews should be conducted to confirm the adequacy and completeness of LTM data and verify the effectiveness of this remediation approach. There also may be administrative concerns associated with long-term enforcement of groundwater use restrictions. Site access is currently restricted and will continue to be restricted for those portions of the groundwater plume beneath the flight line. Therefore, with the exception of any subsurface work at the site, the risk of exposure to fuel hydrocarbons for Base personnel is low. If required, the public and the regulators would have to be informed of the benefits and limitations of the RNA option. Educational programs are not difficult to implement. Where the effectiveness of this option has been supported, the initial regulatory reaction to this alternative has been positive.

6.4.1.3 Cost

The estimated cost of Alternative 1 is summarized in Table 6.3. Capital costs are limited to the construction of 9 new LTM wells and 6 new POC wells (described in Section 7). Included in the $282,929 total present worth cost estimate for Alternative 1

are the costs of maintaining institutional controls and long-term groundwater monitoring at 21 LTM and 6 POC wells for a total of 22 years. LTM monitoring at Zone 1 is expected to be eliminated after 22 years as a result of BTEX plume attenuation to levels that comply with MCP GW-2 standards. It is recommended that conditions at Zone 1 be reevaluated after 10 years of LTM because model predictions of the fate and transport of groundwater contamination at the study area are conservative, and groundwater remediation may be faster than predicted. If the groundwater plume at the site recedes more rapidly than predicted or is below GW-2 remediation levels after 10 years of LTM, then monitoring may be eliminated.

TABLE 6.3
ALTERNATIVE 1 - COST ESTIMATE
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Capital Costs	Cost
Design/Construct 9 LTM and 6 POC Wells	$35,280
Monitoring Costs (per Sampling Event)	**Cost per Event**
Conduct Groundwater Sampling at 27 wells (annually for first 5 years and every other year for remaining 17 years)	$20,622
Maintain Institutional Controls/Public Education (22 years)	$5,000
Project Management and Reporting (22 years)	$5,320
Present Worth of Alternative 1 [a/]	**$282,929**

[a/] Based on an annual adjustment factor of 7 percent (USEPA, 1993).

6.4.2 Alternative 2 - Passive Mobile LNAPL Recovery and Institutional Controls with Long-Term Groundwater Monitoring

6.4.2.1 Effectiveness

The effectiveness of RNA and institutional controls with LTM is discussed for Alternative 1 in Section 6.4.1.1. Passive mobile LNAPL recovery is used for reducing the quantity of the source and controlling plume migration. The goal of LNAPL recovery is to remove this source of continuing BTEX contamination so that RNA of dissolved contaminants in the groundwater can proceed without the continual infusion of additional contaminants. Modeling of a decreasing mobile LNAPL source term suggests that reduction of the source would enhance the effectiveness of RNA and expedite the decrease in the size of the BTEX plume.

To illustrate the impact of passive LNAPL source reduction activities upon dissolved BTEX migration, the Bioplume II model Passive incorporates decreasing BTEX loading rates, under the assumption that a passive LNAPL recovery system will be used to remove the mobile LNAPL present at the SS-16 source area. Passive LNAPL recovery is more feasible than an active recovery system such as a product slurper because of the small quantity of product present. The removal of the mobile LNAPL would decrease the amount of continuing BTEX dissolution into groundwater. Mobile LNAPL recovery was simulated in the model through an annual 50-percent geometric reduction in BTEX loading rates at SS-16 over a 2-year period.

Model Passive was run with 68 pumping periods. The first 23 periods duplicate the calibrated model. The remaining pumping periods each last 1 year and include BTEX loading rates that decrease geometrically at approximately 5 percent per year, except at the source cells for SS-16, where a geometric source decay rate of 50 percent per year was used for pumping periods 24 and 25. While it is difficult to quantify the actual decrease in the BTEX loading rates that could be brought about by mobile LNAPL

recovery, a model based on these assumptions can provide a useful indication of the potential effects of source reduction on dissolved plume fate.

This model predicts a more rapid decrease in BTEX concentrations and a slightly smaller plume areal extent than predicted for RNA alone. Figure 6.2 presents passive model results for the years 2001 (5 years after implementation of mobile LNAPL recovery), 2010 (13 years after implementation of LNAPL recovery), and 2013 (16 years after implementation of LNAPL recovery). Five years after implementation of LNAPL recovery, the maximum source-area BTEX concentration has decreased 45 percent, from approximately 15,600 µg/L to 8,530 µg/L. However, the model predicts that the downgradient BTEX plume extent (as defined by the 5-µg/L contour) will be 300 feet farther downgradient from the calibrated plume extent and remain approximately steady for the duration of the simulation. The maximum predicted BTEX concentration in year 2010 is 80 percent less than the calibrated model. After 16 years of passive remediation, the plume is confined to the SS-19 source area, and the maximum simulated BTEX concentration (2,150 µg/L) lies within that source area. The model predicts that the maximum BTEX concentration will be less than 2,000 µg/L 17 years after the start of passive mobile LNAPL recovery activities.

Alternative 2 should provide reliable, continuous protection with little risk from temporary system failures because a passive LNAPL recovery system requires minimal maintenance. This alternative also complies with AFCEE program goals because RNA remains the predominant remediation method for fuel hydrocarbons dissolved in groundwater at the site. This remedial alternative, however, will result in the recovery of mobile LNAPL that will require treatment and/or disposal.

6.4.2.2 Implementability

Installing and operating a passive LNAPL recovery system to reduce free-phase fuel hydrocarbons in the source areas is more complex than Alternative 1; however, major

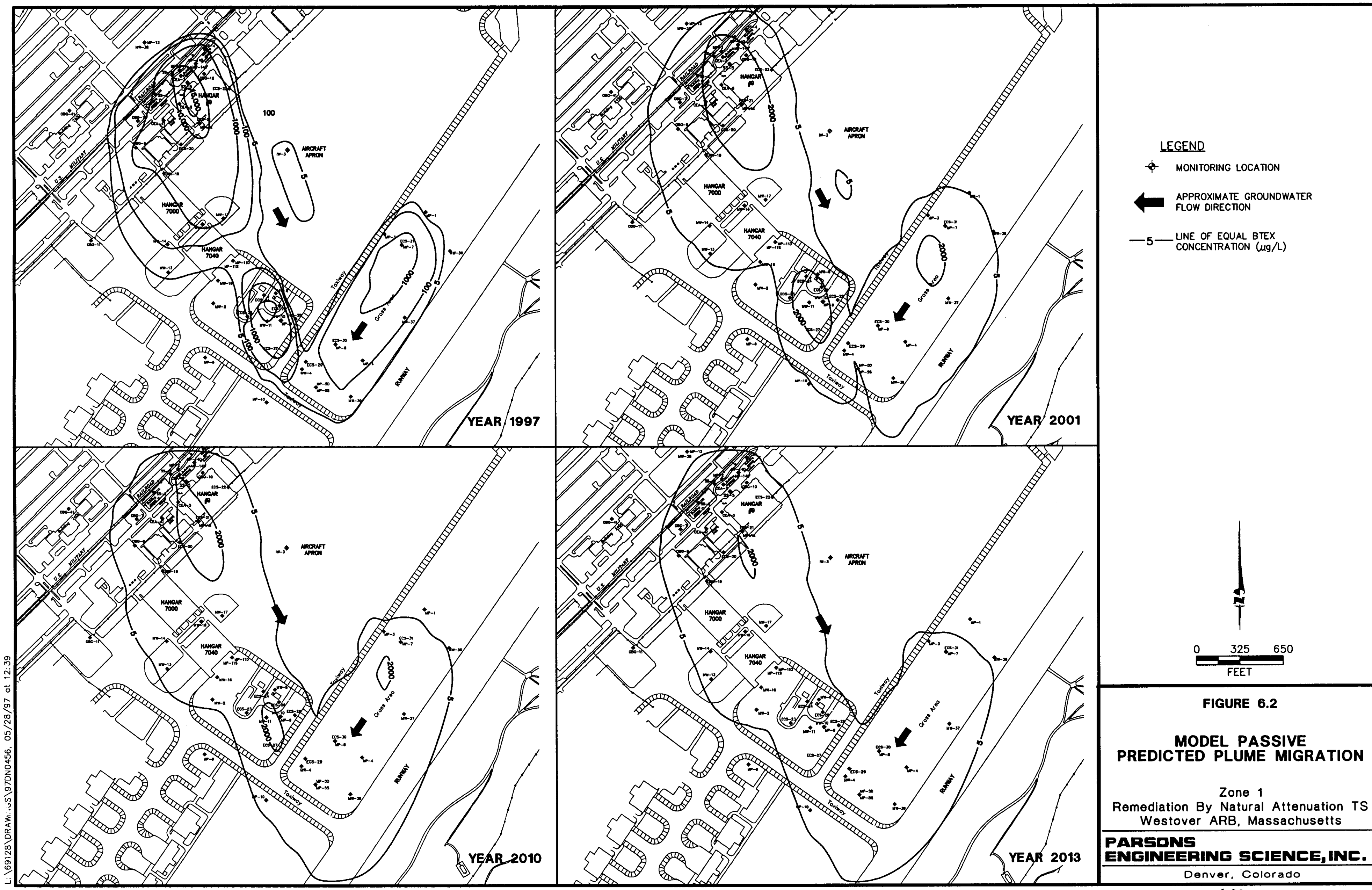

FIGURE 6.2

MODEL PASSIVE PREDICTED PLUME MIGRATION

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

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obstacles are not anticipated. Installation of the recovery system in an existing well involves standard engineering design and construction. Installation and operation of the recovery system would require an increased commitment of labor hours and other resources to maintain and monitor the system. Periodic maintenance would be required, and regular system checks would be needed to dispose of the recovered LNAPL. It is conservatively estimated that the recovery system would be operational for 2 years. The technical and administrative implementability concerns associated with RNA and LTM components of this remedial alternative are similar to those discussed for Alternative 1.

6.4.2.3 Cost

The estimated capital and operating costs of Alternative 2 are shown in Table 6.4. The total present-worth cost of Alternative 2 is $269,972. The cost of Alternative 2 is decreased from the costs of Alternative 1 by the decrease in the number of required sampling events. It is assumed that the passive product recovery system would be operated for 2 years after installation. LTM is assumed to occur annually for the first 5 years, and every second year for the remaining 11 years to ensure that RNA is reducing BTEX concentrations to below regulatory criteria throughout the groundwater plume and to verify that contamination does not reach the POC wells. The capital expense and annual costs for LTM and institutional controls are assumed to be the same as for Alternative 1.

6.4.3 Alternative 3 -Groundwater Extraction, Mobile LNAPL Recovery, RNA, and Institutional Controls with Long-Term Groundwater Water Monitoring

6.4.3.1 Effectiveness

The effectiveness of Alternative 3 depends not only one the effectiveness of mobile LNAPL recovery, RNA, institutional controls, and LTM as already described, but also on the effectiveness of groundwater extraction. Groundwater extraction is an established technology for removing dissolved contaminant mass and controlling plume

TABLE 6.4
ALTERNATIVE 2 - COST ESTIMATE
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

<u>Capital Costs</u>	<u>Cost</u>
Design/Construct 9 LTM and 6 POC Wells	$35,280
Design/Construct 1-Well LNAPL Recovery System	$20,000
<u>Operation, Maintenance, and Monitoring Costs</u>	<u>Cost per annum or event</u>
Operate and Maintain LNAPL Recovery System (2 years)	$7,120
LNAPL Recovery Annual Report (2 years)	$1,420
Conduct Groundwater Sampling at 27 wells (annual for first 5 years and every other year for remaining 11 years)	$20,622
Maintain Institutional Controls/Public Education (16 years)	$5,000
Project Management and Reporting (16 years)	$5,320
<u>Present Worth of Alternative 2</u> [a/]	**$269,972**

[a/] Based on an annual adjustment factor of 7 percent (USEPA, 1993).

migration. The removal of the dissolved BTEX mass would significantly reduce the amount of time required for remediation at Zone 1. However, the dissolved BTEX mass would have to be treated *ex situ* before the extracted groundwater could be disposed of in a sanitary treatment system. An air stripper located at each extraction well was assumed to be sufficient to treat the extracted groundwater.

Model Pump was run to illustrate the scenario of full-scale groundwater extraction and LNAPL source removal at Zone 1. Groundwater extraction with *ex situ* treatment is the least conservative of the three scenarios modeled for this site. This model was

run with 68 pumping periods. As in the two previous models, the first 23 pumping periods duplicate the calibrated model. The next two 1-year pumping periods simulate the passive LNAPL recovery from Alternative 2 and the use of a 2-well groundwater extraction system pumping 50 gallons per minute (gpm). The remaining pumping periods incorporate the natural removal of the remaining sources, and the pumping periods continue to simulate the long-term fate and transport of the dissolved BTEX plume using RNA. The locations of the extraction wells were chosen to reduce the dissolved contamination in the SS-19 source area and to limit the amount of downgradient plume migration near site SS-16. The locations of the two proposed groundwater extraction wells are shown on Figure 6.3.

This model predicts a more rapid decrease in maximum groundwater BTEX concentrations in the source areas over a 5-year period. Figure 6.3 presents model predictions following 1, 3, and 5 years of remediation. Simulated maximum BTEX concentrations for this model decrease approximately 70 percent in the first year, from 15,600 µg/L to 4,600 µg/L. The 3-year simulation (year 2000) predicts source-area BTEX concentrations will decrease by more than 80 percent, to a maximum predicted BTEX concentration of 3,090 µg/L. At year 5 (2002), the model suggests that the plume will have a maximum BTEX concentration of 2,150 µg/L. After 2002, total BTEX levels fall below 2,000 µg/L. Over the 5 years of simulation, the areal extent of the BTEX plume increases slightly, following a slight reduction in plume length during active pumping.

Alternative 3 should provide reliable, continuous protection with little risk from temporary system failures. This alternative, however, does not comply well with all of the AFCEE program goals because of the generation of liquid waste requiring treatment and disposal. As with Alternatives 1 and 2, this alternative would require RNA with LTM and institutional controls to remediate the contaminated groundwater.

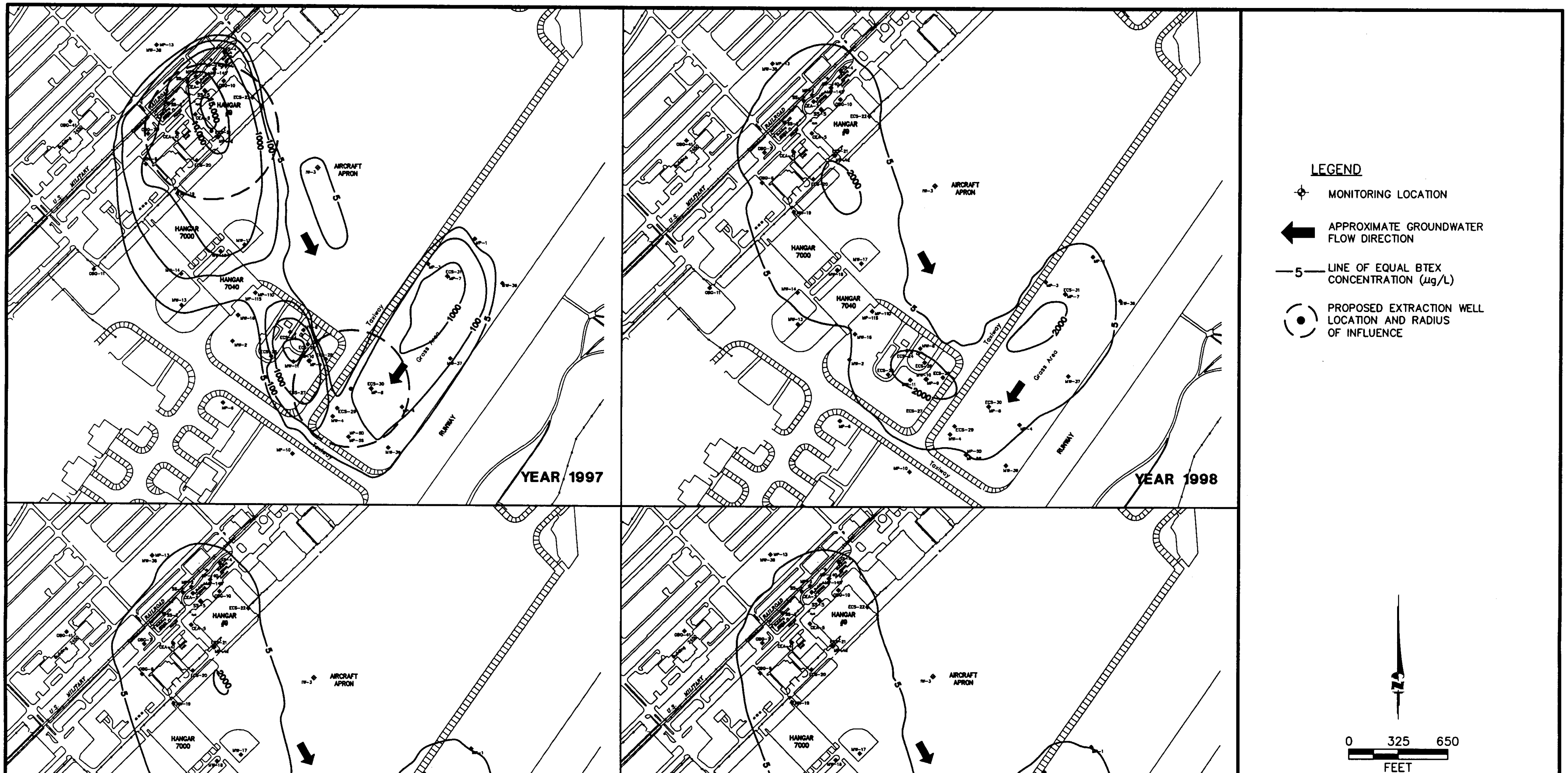

FIGURE 6.3

MODEL PUMP
PREDICTED PLUME MIGRATION

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

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6.4.3.2 Implementability

Groundwater extraction would be labor intensive and expensive to implement. The option would require additional site investigation, design and engineering, installation and a weekly commitment to operation and maintenance of the extraction and air stripper systems. The technical and administrative implementability concerns associated with the RNA, LTM, and institutional controls of this remedial alternative are similar to those discussed in Alternatives 1 and 2.

TABLE 6.5
ALTERNATIVE 3 COST ESTIMATE
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Capital Costs	**Cost**
Design/Construct 9 LTM and 6 POC Wells	$35,280
Construct Groundwater Extraction Wells and Air Stripper Systems	$112,985
Operation, Maintenance, and Monitoring Costs	**Cost per annum or event**
Groundwater Extraction System Operation and Maintenance (2 years)	$31,131
Groundwater Extraction System Reporting	$5,675
Operate and Maintain LNAPL Recovery System (2 years)	$7,120
LNAPL Recovery Annual Report (2 years)	$1,420
Conduct Groundwater Sampling at 27 wells (annually for 5 years)	$20,622
Maintain Institutional Controls/Public Education (5 years)	$5,000
Project Management and Reporting (5 years)	$5,320
Present Worth of Alternative 3 [a/]	**$351,994**

[a/] Based on an annual adjustment factor of 7 percent (USEPA, 1993).

6.4.3.3 Cost

The estimated capital and operating costs of Alternative 3 are shown in Table 6.5. The total present worth cost of Alternative 3 is $351,994. The cost of Alternative 3 is increased from the costs of Alternative 2 by the addition of the groundwater extraction and air stripper treatment system. The cost could be significantly higher if off-gas treatment for the air stripper is required. The present worth cost for LTM and institutional controls is lower than Alternatives 1 and 2 because of the reduced groundwater monitoring time. The annual costs for LTM and institutional controls are assumed to be the same as for Alternatives 1 and/or 2.

6.5 RECOMMENDED REMEDIAL APPROACH

Three remedial alternatives have been evaluated for remediation of the shallow groundwater at the study area. Components of the alternatives evaluated include groundwater extraction, mobile LNAPL recovery, RNA with LTM of groundwater, and institutional controls. Table 6.6 summarizes the results of the evaluation based upon effectiveness, implementability, and cost criteria. Despite the increase in estimated remediation time from Alternatives 2 and 3, the Air Force recommends Alternative 1 as the most cost-effective option for risk reduction at zone 1.

The first two alternatives make maximum use of natural attenuation mechanisms to reduce dissolved BTEX plume mass and migration. Alternative 3 relies on RNA to remediate low dissolved BTEX concentrations along the plume margins; however, the alternative relies on groundwater extraction to reduce dissolved contaminant concentrations through the plume's core. In addition, Alternatives 2 and 3 would use active *ex situ* treatment techniques to reduce the magnitude of continuing sources. Implementation of Alternatives 2 and 3 would decrease the time frame for BTEX remediation, but both alternatives would require greater capital expenditures. Furthermore, the *ex-situ* remediation methods may potentially expose Base personnel to site-related contaminants through accidental contact with removed contaminants.

TABLE 6.6
SUMMARY OF REMEDIAL ALTERNATIVES EVALUATION
GROUNDWATER REMEDIATION
ZONE 1
REMEDIATION BY NATURAL ATTENUATION
WESTOVER ARB, MASSACHUSETTS

Remedial Alternative	Effectiveness	Implementability	Present Worth Cost Estimate
Alternative 1			
- RNA - Long-Term Monitoring - Institutional Controls	Contaminant mass, volume, and toxicity will be significantly reduced and plume will recede. GW-2 standards for BTEX are not likely to be exceeded at POC wells.	Readily implementable. Long-term management, groundwater use controls and monitoring required for an estimated 22 years. Minimal exposure of site workers if any future excavation is carefully controlled in source area. If GW-2 levels are exceeded at POC wells, additional remedial work may be required.	$282,929
Alternative 2			
- LNAPL Recovery - RNA - Long-Term Monitoring - Institutional Controls	Similar to Alternative 1, with the addition of a passive LNAPL recovery system. BTEX mass, volume, and toxicity will be reduced more rapidly than in Alternative 1.	Readily implementable. Installation of LNAPL recovery system should present no problems. LNAPL recovery estimated to continue for 2 years. Long-term management, groundwater controls, and monitoring required for an estimated 16 years. If GW-2 levels are exceeded at POC wells, additional remedial work may be required.	$269,972
Alternative 3			
- Groundwater Extraction - LNAPL Recovery - RNA - Long-Term Monitoring - Institutional Controls	Similar to Alternative 2, with addition of a groundwater extraction system to further reduce BTEX mass throughout the plume. Contaminant mass, volume, and toxicity will be	Readily implementable. Groundwater extraction should present no technical problems and the other components are the same as above. Long-term management, groundwater controls, and monitoring required for an	$351,994

Alternative 3 is considered the least favorable of the three evaluated alternatives because groundwater extraction simply transfers dissolved contamination to gaseous phase rather than reducing contaminants to innocuous byproducts.

All three remedial alternatives are implementable and effectively reduce potential hydrocarbon migration and toxicity in the groundwater. All three alternatives should be acceptable to the public and regulatory agencies because they are protective of human health and the environment and reduce soil and groundwater contamination. Implementation of Alternative 1, or any of the three alternatives, will require land use and groundwater use controls to be enforced. Groundwater monitoring would be required for the respective projected cleanup periods. The maximum estimated 22-year remediation time for Alternative 1 is considered to be conservative because the model assumes the plume is entirely benzene. Because the current benzene concentrations are less than 25 percent of the total dissolved BTEX at the site, the groundwater model may overestimate the time required to reduce benzene concentrations. Because the 22-year estimate is believed to be conservative, the proposed LTM period is consistent with federal recommendations that proposed or implemented remedial activities at a site should not exceed 30 years in duration (USEPA, 1988).

The final evaluation criterion used to compare each of the remedial alternatives was cost. It is the opinion of the Air Force that the additional cost of Alternative 3 does not justify the reduced risk resulting from the decrease in the time required to remediate the dissolved BTEX plume and the residual LNAPL contamination. Future exposure to potential receptors at the site will be minimal because of the restricted access to the flightline portions of Zone 1. Access to the site and the surrounding area is controlled by Base security. Although Alternative 2 is less expensive, it was not selected because it would require collection and disposal of LNAPL that will not be a risk to current and future receptors. Alternative 1 will cost effectively reduce the level of contamination and maintain the necessary degree of protection for potential receptors at the site, and is

the recommended remedial alternative for Zone 1. A LTM plan for groundwater, including a generic Sampling and Analysis Plan (SAP), is provided in Section 7.

SECTION 7

LONG-TERM MONITORING PLAN

7.1 OVERVIEW

In keeping with the requirements of the preferred remedial alternative for Zone 1 at Westover ARB (natural attenuation, institutional controls, and LTM), a long-term groundwater monitoring plan was developed. The purposes of this component of the preferred remedial alternative for the site are to assess site conditions over time, confirm the effectiveness of natural processes at reducing contaminant mass and minimizing contaminant migration, assess compliance with regulatory cleanup goals, and evaluate the need for additional remediation.

The LTM plan consists of identifying the locations of two separate groundwater monitoring networks and developing a groundwater sampling and analysis strategy to demonstrate attainment of site-specific remediation goals and to verify the predictions of the Bioplume II model developed for Zone 1. The strategy described in this section is designed to monitor plume migration over time and to verify that natural attenuation rates are sufficient to protect potential receptors. In the event that data collected under this LTM program indicate that natural processes are insufficient to protect human health and the environment, contingency controls to augment the beneficial effects of natural attenuation would be necessary.

7.2 MONITORING NETWORKS

Two sets of wells will be utilized at the site as part of the LTM component of the remedial alternative. The first set will consist of 21 LTM wells located in, upgradient,

and downgradient from the observed contaminant plume to verify that natural attenuation is occurring at rates sufficient to minimize plume expansion and reduce BTEX concentrations. This network of wells will consist of 16 monitoring wells screened across the water table (shallow wells) to provide short-term confirmation of the effectiveness of natural attenuation. The remaining five wells will be screened in deeper saturated intervals of the surficial aquifer. The second set of wells will consist of six POC wells clustered at three locations along a line perpendicular to the general direction of groundwater flow, approximately 600 feet south of monitoring well MW-39. The purpose of the POC wells is to verify that no BTEX or chlorinated solvent concentrations exceeding state criteria migrate beyond the area under institutional control. Conservative model results suggest that the BTEX plume front should not reach the POC wells.

7.2.1 Long-Term Monitoring Wells

Twenty-one wells at 19 locations within, upgradient, and downgradient from the current BTEX and chlorinated solvent contaminant plumes will be used to monitor the effectiveness of natural attenuation in reducing total contaminant mass and minimizing contaminant migration at Zone 1. Of the 21 wells proposed for the LTM network, 12 have been installed during previous investigations. The remaining 9 wells would be installed upon implementation of this plan. Figure 7.1 identifies the proposed locations of the wells to be used for LTM. Location, type and purpose for each proposed long-term monitoring well is described in Table 7.1. This network will supplement the POC wells to provide evidence of continuing natural attenuation and to allow sufficient response time if site conditions change.

The nine new monitoring wells will have 10-foot screened intervals. Shallow wells will be screened across the water table with approximately 8 feet of the 10-foot screen positioned below the water table. Deep wells will be screened in the medium to coarse sand hydrogeologic unit at a depth of approximately 40 feet.

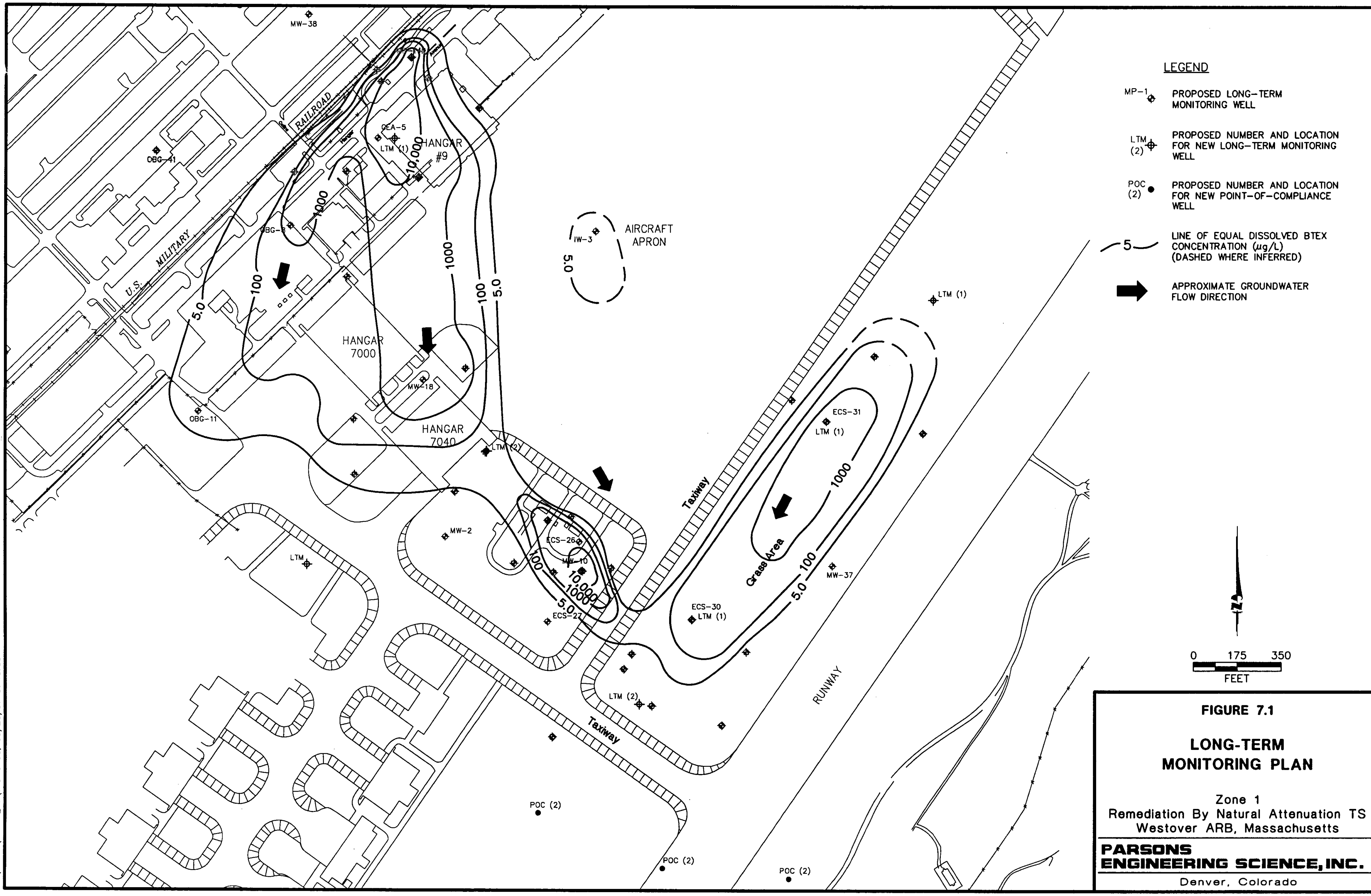

FIGURE 7.1

LONG-TERM MONITORING PLAN

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

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TABLE 7.1
PROPOSED LONG-TERM MONITORING WELLS
Zone 1
Remediation by Natural Attenuation TS
Westover ARB, Massachusetts

Existing LTM Well ID	Proposed LTM Wells	Type of LTM Well					Comments
		Site Association	Upgradient	Flow Path/ Treatment Zone	Extent/ Plume Fringe	Source Area	
MW-38		SS-19	X				
	LTM(D)[a]	SS-19				X	Vertical control for SS-19 contamination at CEA-5
CEA-5		SS-19				X	Highest dissolved BTEX concentration at SS-19 in November 1996
OBG-8		SS-19				X	
OBG-11		SS-19			X		Confirmation of lateral extent of SS-19 contaminant plume
MW-18		SS-19		X			
	LTM(S)	SS-19			X		
IW-3		WP-15				X	Source area of dissolved chlorinated solvent contamination
	LTM (S,D)	WP-15			X		
MW-2		WP-15			X		
ECS-27		West SS-16					
ECS-26		West SS-16				X	Free product observed in well in November 1996
ECS-10		West SS-16				X	Highest dissolved BTEX concentration at SS-16 in November 1996
	LTM(S)	East SS-16	X		X		
ECS-31		East SS-16				X	
	LTM(D)	East SS-16				X	Vertical control of dissolved contamination at ECS-31
ECS-30		East SS-16		X			
	LTM(D)	East SS-16		X			Vertical control of dissolved contamination at ECS-30
	LTM(S,D)	East SS-16			X		

[a] S = proposed shallow long-term monitoring well
D = proposed deep long-term monitoring well

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7.2.2 Point-of-Compliance Wells

Three POC monitoring well clusters are proposed for installation at the site. Figure 7.1 shows proposed locations for these clusters. It is recommended that the POC wells be installed upon implementation of this plan. The locations presented on Figure 7.1 are approximately 800 to 1000 feet downgradient of the current leading edge of the BTEX plume. These locations are approximately 2,000 feet upgradient, along the observed groundwater flow path, from Cooley Brook, which is located south and southeast of Zone 1. The POC wells are more than 2,000 feet and 5,000 feet from the eastern and southern Base boundaries, respectively.

The purpose of POC wells is to verify that no contaminated groundwater exceeding state criteria migrates beyond the area under institutional control. Although model results strongly suggest that the contaminant plume will not migrate beyond the POC at concentrations exceeding chemical-specific MCP standards, these POC wells are the technical mechanisms used to demonstrate protection of human health and the environment and compliance with site-specific groundwater standards [i.e., 2,000 μg/L benzene (OB&G 1997)].

As with the LTM wells, the POC wells will be screened in the same hydrogeologic units as the contaminant plumes. Data presented in this report concerning the nature and extent of contamination at the site suggest that a 10-foot screen with approximately 8 feet of screen below the groundwater surface will be sufficient to intercept the contaminant plume in the shallow groundwater at this site. Deep POC wells will use a 10-foot screen placed approximately 40 feet bgs in the glacial outwash aquifer.

7.3 GROUNDWATER SAMPLING

To ensure that sufficient contaminant removal is occurring at Zone 1 to meet site-specific remediation goals, the long-term groundwater monitoring plan includes a generic sampling and analysis plan. Reductions in toxicity will be implied by mass

reduction. The sampling and analysis plan also is aimed at assuring natural attenuation can achieve site-specific concentration goals for BTEX and chlorinated solvent compounds.

7.3.1 Analytical Protocol

All LTM and POC wells in the LTM program will be sampled and analyzed to determine compliance with chemical-specific remediation goals and to verify the effectiveness of natural attenuation at the site. Groundwater and LNAPL measurements will be made in all sampled wells during each sampling event. Groundwater samples will be analyzed for the parameters listed in Tables 7.2 and 7.3. A site-specific groundwater sampling and analysis plan should be prepared prior to initiating the LTM program.

7.3.2 Sampling Frequency

Each of the LTM and POC will be sampled once every year for 5 years. If the data collected during these 5 years supports the anticipated effectiveness of natural attenuation at Zone 1, the sampling frequency for all wells in the LTM program can be reduced to once every other year for another 17 years. If at any time the data suggest that dissolved BTEX concentrations have decreased to below groundwater II standards the sampling frequency may be reduced or LTM monitoring may be eliminated. On the other hand, if the data collected at any time during the monitoring period indicate the need for additional remedial activities at the site, the sampling frequency should be adjusted accordingly.

TABLE 7.2
LONG-TERM GROUNDWATER MONITORING ANALYTICAL PROTOCOL
Zone 1
Remediation by Natural Attenuation TS
Westover ARB, Massachusetts

Analyte	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Ferrous Iron (Fe^{2+})	Colorimetric A3500-Fe D	Field only	Elevated ferrous iron concentrations may be indicative of the anaerobic biodegradation process of iron reduction	Every Year for 5 years, then every other year for 17 additional years	Collect 100 mL of water in a glass container; acidify with hydrochloric acid per method	Field
Ferrous Iron (Fe^{2+})	Colorimetric Hach 25140-25	Alternate method; field only	Same as above.	Every Year for 5 years, then every other year for 17 additional years	Collect 100 mL of water in a glass container	Field
Temperature	E170.1	Field only	Metabolism rates for microorganisms depend on temperature	Every Year for 5 years, then every other year for 17 additional years	N/A	Field
Dissolved Oxygen	Dissolved oxygen meter	Refer to Method A4500 for a comparable laboratory procedure	The oxygen concentration is an indicator of biodegradation conditions; concentrations less than 1 mg/L generally indicate an anaerobic pathway	Every Year for 5 years, then every other year for 17 additional years	Collect 300 mL of water in biochemical oxygen demand bottles; analyze immediately; alternately, measure dissolved oxygen in situ	Field
pH	E150.1/SW9040, direct reading meter	Protocols/Handbook methods[a/]	Aerobic and anaerobic processes are pH-sensitive	Every Year for 5 years, then every other year for 17 additional years	Collect 100–250 mL of water in a glass or plastic container; analyze immediately	Field
Conductivity	E120.1/SW9050, direct reading meter	Protocols/Handbook methods	General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system	Every Year for 5 years, then every other year for 17 additional years	Collect 100–250 mL of water in a glass or plastic container	Field
Nitrate (NO_3^{-1})	IC method E300 or method SW9056; colorimetric, method E353.2	Method E300 is a Handbook method; method SW9056 is an equivalent procedure	Substrate for microbial respiration if oxygen is depleted	Every Year for 5 years, then every other year for 17 additional years	Collect up to 40 mL of water in a glass or plastic container; cool to 4°C; analyze within 48 hours	Fixed-base

TABLE 7.2 (Concluded)
LONG-TERM GROUNDWATER MONITORING ANALYTICAL PROTOCOL
Zone 1
Remediation by Natural Attenuation TS
Westover ARB, Massachusetts

Analyte	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Sulfate (SO_4^{2-})	IC method E300 or method SW9056 or Hach SulfaVer 4 method	Method E300 is a Handbook method; method SW9056 is an equivalent procedure. Hach method is photometric	Substrate for anaerobic microbial respiration	Every Year for 5 years, then every other year for 17 additional years	Collect up to 40 mL of water in a glass or plastic container; cool to 4°C	Fixed-base or field (for Hach method)
Redox potential	A2580 B	Measurements are made with electrodes; results are displayed on a meter; samples should be protected from exposure to atmospheric oxygen	The redox potential of groundwater influences and is influenced by biologically mediated reactions; the redox potential of groundwater may range from more than 200 mV to less than -400 mV	Every Year for 5 years, then every other year for 17 additional years	Collect 100–250 mL of water in a glass container, filling container from bottom; analyze immediately	Field
Methane, Ethane, and Ethene	RSKSOP-114 modified to analyze water samples for methane by headspace sampling with dual thermal conductivity and flame ionization detection.	Method published and used by the USEPA NRMRL	The presence of methane suggests BTEX degradation via an anaerobic pathway utilizing carbon dioxide (carbonate) as the electron acceptor (methanogenesis).	Every Year for 5 years, then every other year for 17 additional years	Collect water samples in 40 mL volatile organic analysis (VOA) vials with butyl gray/Teflon-lined caps (zero headspace); cool to 4°C	Fixed-base
Aromatic hydrocarbons (BTEX)	Purge and trap GC Method SW8020.	Handbook method; analysis may be extended to higher molecular weight alkylbenzenes	BTEX is the primary target analyte for monitoring natural attenuation; BTEX concentrations must also be measured for regulatory compliance	Every Year for 5 years, then every other year for 17 additional years	Collect water samples in a 40 mL VOA vial with zero headspace; cool to 4°C; add hydrochloric acid to pH ≤ 2	Fixed-base
Volatile Organics	GS/MS Method 8240	Handbook method	Measured for regulator compliance	Every Year for 5 years, then every other year for 17 additional years	Collect water samples in a 40 mL VOA vial; cool to 4°C; add hydrochloric acid to pH < 2	

a/ Protocol methods are presented by Wiedemeier *et al.* (1995).

TABLE 7.3
POINT-OF-COMPLIANCE GROUNDWATER MONITORING ANALYTICAL PROTOCOL
Zone 1
Remediation by Natural Attenuation TS
Westover ARB, Massachusetts

Analyte	Method/Reference	Comments	Data Use	Recommended Frequency of Analysis	Sample Volume, Sample Container, Sample Preservation	Field or Fixed-Base Laboratory
Temperature	E170.1	Field only	Well development	Every Year for 5 years, then every other year for 17 additional years	N/A	Field
Dissolved Oxygen	Dissolved oxygen meter	Refer to method A4500 for a comparable laboratory procedure	The oxygen concentration is an indicator of biodegradation conditions; concentrations less than 1 mg/L generally indicate an anaerobic pathway	Every Year for 5 years, then every other year for 17 additional years	Collect 300 mL of water in biochemical oxygen demand bottles; analyze immediately; alternately, measure dissolved oxygen in situ	Field
pH	E150.1/SW9040, direct-reading meter	Protocols/Handbook methods[a/]	Aerobic and anaerobic processes are pH-sensitive	Every Year for 5 years, then every other year for 17 additional years	Collect 100–250 mL of water in a glass or plastic container; analyze immediately	Field
Conductivity	E120.1/SW9050, direct-reading meter	Protocols/Handbook methods	General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system	Every Year for 5 years, then every other year for 17 additional years	Collect 100–250 mL of water in a glass or plastic container	Field
Aromatic hydrocarbons (BTEX)	Purge and trap GC Method SW8020	Handbook method; analysis may be extended to higher molecular weight alkylbenzenes	BTEX are the primary target analytes for monitoring natural attenuation; BTEX concentrations must also be measured for regulatory compliance	Every Year for 5 years, then every other year for 17 additional years	Collect water samples in a 40 mL VOA vial with zero headspace; cool to 4°C; add hydrochloric acid to pH ≤ 2	Fixed-base
Volatile Organics	GC Method SW8010 or GC/MS Method SW 8240	Handbook method	Measured for regulatory compliance	Every Year for 5 years, then every other year for 17 additional years	Collect water samples in a 40 mL VOA vial; cool to 4°C; add hydrochloric acid to pH < 2	

[a/] Protocol methods are presented by Wiedemeier *et al.* (1995).

SECTION 8

CONCLUSIONS AND RECOMMENDATIONS

This report presents the results of a TS conducted to evaluate the use of RNA of fuel-hydrocarbon- and chlorinated solvent-contaminated groundwater at the IRP sites SS-16, SS-19, and WP-15 (Zone 1), Westover ARB, Massachusetts. Specifically, the finite-difference groundwater model Bioplume II was used in conjunction with site-specific geologic, hydrologic, and laboratory analytical data to simulate the migration and biodegradation of BTEX compounds dissolved in groundwater.

Geochemical of evidence was used to document RNA at Zone 1. Comparison of BTEX, electron acceptor, and biodegradation byproduct isopleth maps for Zone 1 provides strong geochemical evidence of biodegradation of both BTEX. Geochemical data strongly suggest that biodegradation of fuel hydrocarbons is occurring at the site via aerobic respiration and the anaerobic processes of denitrification, iron reduction, sulfate reduction, and methanogenesis. Rates of biodegradation were estimated from observed contaminant concentrations and the method of Buscheck and Alcantar (1995).

To obtain the data necessary for the RNA demonstration, Parsons ES collected and analyzed soil and groundwater samples from the site. Site-specific geologic, hydrologic, and laboratory analytical data were then used in the Bioplume II numerical groundwater model to simulate the effects of advection, dispersion, sorption, and biodegradation on the fate and transport of the dissolved BTEX plume. Extensive site-specific data were used for model implementation. Model parameters that could not be obtained from existing site data were estimated using widely accepted literature values for aquifer materials similar to those found at the site. Conservative aquifer parameters

were used to construct the Bioplume model for this site. Therefore, the model results presented herein represent conservative predictions of groundwater BTEX plume fate and transport.

For one model simulation (model RNA), it was assumed that conditions that produced the calibrated model would persist for the duration of the simulation. This scenario suggests that the plume mass is decreasing, and the plume will migrate approximately 500 feet downgradient from the observed September 1996 extent. The model predicts that natural attenuation of the dissolved BTEX plume to below the Massachusetts GW-2 benzene standard will occur in 22 years. Model Passive assumed a contaminant source reduction through mobile LNAPL recovery at the SS-16 source area, using a geometric source decay rate of 50 percent per year for 2 years. Results for this model suggest that the plume will migrate approximately 300 feet beyond the September 1996 position and source area dissolved BTEX concentrations will be below the 2,000-µg/L state GW-2 standard for benzene 16 years after the implementation of the mobile LNAPL recovery/RNA remedial alternative. A third model (Pump) assumed groundwater extraction at the SS-19 source area and downgradient from SS-16 would rapidly remove dissolved BTEX. Model Pump predicts that the dissolved BTEX plume will attenuate to below the benzene GW-2 level in just over 5 years.

The results of this study suggest that RNA of dissolved BTEX compounds is occurring at Zone 1. Given that the models predict no impact on known receptors at the modeled rates of BTEX plume migration, the Air Force recommends RNA, institutional controls, and LTM to remediate site groundwater impacted by BTEX and CAH. The estimated rates of biodegradation, when coupled with sorption, dispersion, and dilution, should be sufficient to reduce and maintain dissolved BTEX and CAH concentrations to levels below current regulatory standards long before potential downgradient receptors could be adversely affected. Construction activities in the plume area and groundwater use in and downgradient from the plume area should be

restricted for a period of at least 22 years or until groundwater contaminant concentrations decrease below MCP GW-2 levels for BTEX.

To verify the results of the Bioplume II modeling effort, and to ensure that RNA is occurring at rates sufficient to protect potential downgradient receptors, groundwater from 21 LTM wells should be sampled and analyzed for the parameters listed in Table 7.1. In addition, six proposed monitoring wells downgradient from the current BTEX plume location should be designated as the POC and sampled for the parameters listed in Table 7.2. Figure 7.1 shows suggested locations for the POC and LTM wells. These wells should be sampled annually for the first 5 years, and every other year for the remaining 17 years. After 10 years, the results from LTM should be evaluated to determine whether sampling should cease, decrease in frequency, or continue at the rate of every second year. If dissolved BTEX concentrations in groundwater collected from the POC wells exceed regulatory criteria, additional evaluation or corrective action may be necessary at this site.

SECTION 9

REFERENCES

Altenschmidt, U. and Fuchs, G., 1991, Anaerobic degradation of toluene in denitrifying *Pseudomonas* sp.: Indication for toluene methylhydroxylation and benzoyl-CoA as central aromatic intermediate: Arch. Microbial., vol. 156, p. 152-158.

Alvarez, P.J.J., and Vogel, T.M., 1991, Substrate interactions of benzene, toluene, and para-xylene during microbial degradation by pure cultures and mixed culture aquifer slurries: Applied Environmental Microbiology, vol. 57, p. 2981-2985.

Alvarez-Cohen, L.M. and McCarty, P.L., 1991a, Effects of toxicity, aeration, and reductant supply on trichloroethylene transformation by a mixed methanotrophic culture: Appl. Environ. Microbiol., vol. 57, no. 1, p. 228-235.

Alvarez-Cohen, L.M., and McCarty, P.L., 1991b, Product toxicity and cometabolic competitive inhibition modeling of chloroform and trichloroethylene transformation by methanotrophic resting cells: Appl. Environ. Microbiol., vol. 57, no. 4, p. 1031-1037.

Arciero, D., Vannelli, T., Logan, M., and Hooper, A.B., 1989, Degradation of trichloroethylene by the ammonia-oxidizing bacterium *Nitrosomonas europaea*: Biochem. Biophys. Res. Commun., vol. 159, p. 640-643.

Anderson, M.P. and Woessner, W.W., 1992, Applied Ground Water Modeling - Simulation of Flow and Advective Transport: Academic Press, New York, New York, 381 p.

Arthur D. Little, Inc. 1987. The Installation Restoration Program Toxicology Guide, Volume 3. Prepared for Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, June.

Atlas, R.M., 1981, Microbial degradation of petroleum hydrocarbons - an environmental perspective: Microbiological Reviews, vol. 45, no. 1, p. 180-209.

Atlas, R.M., 1984, Petroleum Microbiology: Macmillan Publishing Company, New York.

Atlas, R.M., 1988, Microbiology - Fundamentals and Applications: Macmillan Publishing Company, New York.

Baedecker, M.J., Siegel, D.I., Bennett, P.C., Cozzarelli, I.M., 1988, The fate and effects of crude oil in a shallow aquifer: I. The distribution of chemical species and geochemical facies, In: G.E. Mallard, and S.E. Ragone, editors, U.S. Geological Survey Toxic Substances Hydrology Program, Proceedings of the Technical Meeting, Phoenix, Arizona, September 26-30, 1988: U.S. Geological Survey Water-Resources Investigations Report 88-42320, p. 29-22.

Baedecker, M.J., and Cozzarelli, I.M., 1991, Geochemical modeling of organic degradation reactions in an Aquifer contaminated with Crude Oil: U.S. Geological Survey Water-Resources Investigations Report 91-4034. Reston, VA. p 627-632.

Ball, H.A., Reinhard, M., and McCarty, P.L., 1991, Biotransformation of monoaromatic hydrocarbons under anoxic conditions, In: In Situ Bioreclamation, Applications and Investigations for Hydrocarbon and Contaminated Site Remediation. Eds. R.E. Hinchee and R.F. Olfenbuttel. Butterworth-Heinemann. Boston, MA. p. 458-463.

Barker, J.F., Patrick, G.C., and Major, D., 1987, Natural attenuation of aromatic hydrocarbons in a shallow sand aquifer: Ground Water Monitoring Review, Winter, 1987, p. 64-71.

Bartha, R., 1986, Biotechnology of petroleum pollutant biodegradation: Microbial Ecology, vol. 12, p. 155-172.

Bauman, B., 1991, Biodegradation research of the American Petroleum Institute. Presented at: In Situ Bioreclamation: Application and Investigation for Hydrocarbons and Contaminated Site Remediation. San Diego, CA. March 19-21, 1991.

Bear, J., 1979, Hydraulics of Groundwater. McGraw-Hill, Inc., New York, New York, 569p.

Beller, H.R. Reinhard, M., and Grbic-Galic, D., 1992, Metabolic byproducts of anaerobic toluene degradation by sulfate-reducing enrichment cultures: Appl. Environ. Microbiol., vol. 58, p. 3192-3195.

Biomedical and Enironmental Information Analysis (BEIA), 1989, The Installation Restoration Program Toxicology Guide, Health and Safety Research Division, Oak Ridge National Laboratory.

Bohon, R.L., and Claussen, W.F., 1951, The solubility of aromatic hydrocarbons in water: Journal of American Chemical Society, vol. 73, no. 4, p. 1571-1578.

Borden, R.C., 1991, Simulation of enhanced in situ biorestoration of petroleum hydrocarbons. In: In Situ bioreclamation: Application and Investigation for Hydrocarbons and contaminated Site Remediation. Eds., R.E. Hinchee and R. F. Olfenbuttel. Butterworth-Heinemann. p. 529-534.

Borden, R.C., and Bedient, P.B., 1986, Transport of dissolved hydrocarbons influenced by oxygen limited biodegradation - theoretical development: Water Resources Research, vol. 22, no. 13, p. 1973-1982.

Bouwer, E.J., 1992, Bioremediation of Subsurface Contaminants, In: Mitchell, R., ed.: Environmental Microbiology. Wiley-Liss, New York, New York.

Bouwer, E.J., 1994, Bioremediation of chlorinated solvents using alternate electron acceptors: In: Handbook of Bioremediation. Lewis Publishers. Boca Raton, FL. 1994.

Bouwer, E.J., Rittman, B.E., and McCarty, P.L., 1981, Anaerobic degradation of halogenated 1- and 2-carbon organic compounds: Environ. Sci. Technol., vol. 15, no. 5, p. 596-599.

Bouwer, E.J. and Wright, J.P., 1988, Transformations of trace halogenated aliphatics in anoxic biofilm columns: J. Contam. Hydrol., vol. 2, p. 155-169.

Bouwer, H., 1989, The Bouwer and Rice slug test - an update: *Ground Water*, 27(3), p. 304-309.

Bouwer, H., and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: *Water Resources Research*, 12(3), p. 423-428.

Bradley, P.M., and Chapelle, F.H., 1996, Anaerobic mineralization of vinyl chloride in Fe(III)-reducing aquifer sediments: Environmental Science and Technology, v. 40, p. 2084-2086.

Brown, R.A., Dey, J.C. and McFarland, W.E., 1991, Integrated site remediation combining groundwater treatment, soil vapor extraction, and bioremediation, In: In Situ Bioreclamation: Application and Investigation for Hydrocarbons and Contaminated Site Remediation. Eds., R.E. Hinchee and R. F. Olfenbuttel. Butterworth-Heinemann. p. 444-449.

Buscheck, T. E., and Alcantar, C. M., 1995, Regression Techniques and Analytical Solutions to Demonstrate Intrinsic Bioremediation. In: Proceedings of the 1995 Battelle International Symposium on In Situ and On-Site Bioreclamation, April 1995.

Buscheck, T. E., O'Reilly, K. T., and Nelson, S. N., 1993, Evaluation of INtrinsic Bioremediation at Field Sites: Proceedings, Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Restoration, pp. 367-381. National Ground Water Association/API, Houston, TX.

CH_2M Hill, 1982, U.S. Air Force Installation Restoration Program Records Search for Westover Air Force Base, April 1982.

Chapelle, F.H., 1993, Ground-water Microbiology and Geochemistry. John Wiley and Sons, Inc., New York, NY.

Chapelle, F.H., 1994, Assessing the Efficiency of Intrinsic Bioremediation, *in* Proceedings of the Symposium on Intrinsic Bioremediation of Ground Water, August 30 - September 1, 1994: US Environmental Protection Agency, p. 171.

Chiang, C.Y., Salanitro, H.P., Chai, E.Y., Colthart, H.D., and Klein, C.L., 1989, Aerobic biodegradation of benzene, toluene, and xylene in a sandy aquifer - data analysis and computer modeling: Ground Water, vol. 27, no. 6, p. 823-834.

Cline, P.V., and Delfino, J.J., 1989, Transformation kinetics of 1,1,1-trichloroethane to the stable product 1,1-dichloroethene, In: Biohazards of Drinking Water Treatment. Lewis Publishers, Inc. Chelsea, MI. p. 47-56.

Corporate Environmental Advisors, Inc.(CEA), 1991, Phase I Limited Site Investigation, Aqua System Site, August.

Cozzarelli, I.M., Eganhouse, R.P., and Baedecker, M.J., 1990, Transformation of monoaromatic hydrocarbons to organic acids in anoxic ground water environment: Environmental and Geological Water Science, vol. 16.

Cozzarelli, I.M., Baedecker, M.J., Eganhouse, R.P., 1994, The geochemical evolution of low-molecular-weight organic acids derived from the degradation of petroleum contaminants in groundwater: Geochimica et Cosmochimica Acta, vol. 58, no. 2, p. 863-877.

Davis, J.W., and Carpenter, C.L., 1990, Aerobic biodegradation of vinyl chloride in groundwater samples: Applied and Environmental Microbiology, v. 56, p. 3878.

Davis, J.W., Klier, N.J., and Carpenter, 1994, Natural biological attenuation of benzene in ground water beneath a manufacturing facility: Ground Water, vol. 32, no. 2, p. 215-226.

DeBruin, W.P., Kotterman, M.J.J., Posthumus, M.A., Schraa, G., and Zehnder, A.J.B., 1992, Complete biological reductive transformation of tetrachloroethene to ethane: Applied and Environmental Microbiology, v. 58, no. 6, p. 1966-2000.

DeStefano, T.D., Gossett, J.M., and Zinder, S.H., 1991, Reductive dechlorination of high concentrations of tetrachloroethene to ethene by an anaerobic enrichment culture in the absence of methanogenesis: Appl. Environ. Microbiol., vol. 57, no. 8, p. 2287-2292.

Edwards, E., Wills, L.E., Grbic-Galic, D., and Reinhard, M., 1991, Anaerobic degradation of toluene and xylene--evidence for sulfate as the terminal electron acceptor, In: In Situ Bioreclamation, Applications and Investigations for Hydrocarbon and Contaminated Site Remediation. Eds. R.E. Hinchee and R.F. Olfenbuttel. Butterworth-Heinemann. Boston, MA. p. 463-471.

Edwards, E.A., and Grbic-Galic, D., 1992, Complete mineralization of benzene by aquifer microorganisms under strictly anaerobic conditions: Appl. Environ. Microbiol., vol. 58, p. 2663-2666.

Edwards, E.A., Wells, L.E., Reinhard, M., and Grbic-Galic, D., 1992, Anaerobic degradation of toluene and xylene by aquifer microorganisms under sulfate-reducing conditions: Appl. Environ. Microbiol., vol. 58, p. 794-800.

Engineering-Science, Inc. (ES), 1986, Installation Restoration Program, Phase II - Technical Operations Plan, September 1986.

ES, 1988, Installation Restoration Program, Phase II - Confirmation/Quantification Stage 2. Final Report, October 1988.

ES, 1993, *Health and Safety Plan for the Bioplume Modeling Initiative*. Prepared for the Air Force Center for Environmental Excellence, Environmnetal Restoration Division, USAF Contract F41624-92-D-8036.

Environmental Compliance Services, Inc.(ECS), 1992, Groundwater Investigations, Westover Air Force Base, Chicopee, Massachusetts, January.

Evans, P.J., Mang, D.T., and Young, L.Y., 1991a, Degradation of toluene and m-xylene and transformation of o-xylene by denitrifying enrichment cultures: Appl. Environ. Microbiol., vol. 57, p.450-454.

Evans, P.J., Mang. D.T., Kim, K.S., and Young, L.Y., 1991b, Anaerobic degradation of toluene by a dentrifying bacterium: Appl. Environ. Microbiol., vol. 57, p. 1139-1145.

Fetter, C.W., 1993, Contaminant Hydrogeology: MacMillan, New York, New York, 458 p.

Folsom, B.R., Chapman, P.J., and Pritchard, P.H., 1990, Phenol and trichloroethylene degradation by *Pseudomonsa cepacia* G4: Kinetics and interactions between substrates: Appl. Environ. Microbiol., vol. 56, no. 5, p. 1279-1285.

Freedman, D.L., and Gossett, J.M., 1989, Biological reductive dechlorination of tetrachloroethylene and trichloroethylene to ethylene under methanogenic conditions: Appl. Environ. Microbiol., vol. 55, no. 4, p. 1009-1014.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Gibson, D.T., and Subramanian, V., 1984, Microbial degradation of aromatic hydrocarbons, In: Gibson, D.T., ed: Microbial Degradation of Organic Compounds, Marcel Dekker, Inc., p. 181-252.

Godsey, E.M., 1994, Microbiological and geochemical degradation processes, In: Symposium on Intrinsic Bioremediation in Ground Water. Denver, CO. August 30 - September 1, 1994, p.35-40.

Grbic´-Galic´, D., 1989, Microbial degradation of homocyclic and heterocyclic aromatic hydrocarbons under conditions: Dev. Ind. Microbiol., vol. 30, p. 237-253.

Grbic´-Galic´, D., 1990, Anaerobic microbial transformation of nonoxygenated aromatic and alicyclic compounds in soil, subsurface, and freshwater sediments, In: Bollag, J.M., and Stotzky, G., eds.: Soil Biochemistry: Marcel Dekker, Inc., New York, NY. p. 117-189.

Grbic'-Galic', D., and Vogel, T.M., 1987, Transformation of toluene and benzene by mixed methanogenic cultures: Applied and Environmental Microbiology, vol. 53, p. 254-260.

Haag, F., Reinhard, M., and McCarty, P.L., 1991, Degradation of toluene and p-xylene in an anaerobic microcosms: Evidence for sulfate as a terminal electron acceptor: Environ. Toxicol. Chem., vol. 10, p. 1379-1389.

Harker, A.R., and Kim, Y., 1990, Trichloroethylene degradation by two independent aromatic-degrading pathways in *Alcaligenes eutrophus* JMP134: Appl. Environ. Microbiol., vol. 56, no. 4, p. 1179-1181.

Hartmans, S., and de Bont, J.A.M., 1992, Aerobic vinyl chloride metabolism in Mycobacterium aurum Li: Appl. Environ. Microbiol., vol. 58, no. 4, p. 1220-1226.

Hassett. J.J., Banwart, W.L., and Griffin, R.A., 1983, Correlation of compound properties with sorption characteristics of nonpolar compounds by soils and sediments; concepts and limitations, In, C.W. Francis and S.I. Auerbach, editors, Environment and Solid Wastes: Butterworths, Boston, p. 161-178.

Henry, S.M., 1991, Transformation of Trichloroethylene by Methanotrophs from a Groundwater Aquifer. Ph.D. Thesis. Stanford University. Palo Alto, California.

Henson, J.M., Yates, M.V., and Cochran, J.W., 1989, Metabolism of chlorinated methanes, ethanes, and ethylenes by a mixed bacterial culture growing on methane: J. Ind. Microbiol., vol. 4, p. 29-35.

Hine, J., and Mookerjee, P.K., 1975, The Intrinsic Hydrophilic Character of Organic Compounds. Correlations in Terms of Structural Contributions: Journal of Organic Chemistry, 40(3): 292-298.

Hopper, D.J., 1978, Incorporation of [^{18}O] water in the formation of p-hydroxybenzyl alcohol by the p-cresol methoylhydroxylase from *Pseudomonas putida*: Biochem. J., 175:345-347.

Hutchins, S.R., and Wilson, J.T., 1991, Laboratory and field studies on BTEX biodegradation in a fuel-contaminated aquifer under denitrifying conditions, In: In Situ Bioreclamation, Applications and Investigations for Hydrocarbon and Contaminated Site Remediation. Eds. R.E. Hinchee and R.F. Olfenbuttel. Butterworth-Heinemann. Boston, MA. p. 157-172.

Hutchins, S.R., Sewell, G.W., Sewell, D.A., Kovacs, D.A., and Smith, G.A., 1991a, Biodegradation of monoaromatic hydrocarbons by aquifer microorganisms using oxygen, nitrate, or nitrous oxide as the terminal electron acceptor: Environ. Sci. Technol., vol. 25, no. 1, p. 68-76.

Hutchins, S.R., Downs, W.C., Smith, G.B., Smith, J.T., Wilson, D.J., Hendrix, D.J., Fine, D.D., Kovacs, D.A., Douglass, R.H., and Blaha, F.A., 1991b, Nitrate for Biorestoration of an Aquifer Contaminated with Jet Fuel. U.S. Environmental Protection Agency. Robert S. Kerr Environmental Research Laboratory. Ada, Oklahoma. epa/600/2-91/009. April, 1991.

Jamison, V.W., Raymond, R.L., and Hudson, J.O. Jr., 1975, Biodegredation of high-octane gasoline in ground water: Developments in Industrial Microbiology, vol. 16.

Jury, W.A., Spencer, W.F., and Farmer, W.J., 1984, Behavior Assessment Model for Trace Organics in Soil: III, Application of Screening Model: Journal of Environmental Quality, 13(4):573-579.

Kenaga, E.E., and Goring, C.A.I., 1980, ASTM Special Technical Publication 707: American Society for Testing Materials, Washington, D.C.

Klier, N.J., West, R.J., and Donberg, P.A., 1996, Aerobic biodegradation of dichloroethylenes in surface and subsurface soils: Accepted for publication in Chemosphere.

Konikow, L.F., 1978, Calibration of ground-water models, *in* Verification of Mathematical and Physical Models in Hydraulic Engineering: American Society of Civil Engineers, New York, pp. 87-93.

Konikow, L.F., and Bredehoeft, J.D., 1978, Computer model of two-dimensional solute transport and dispersion in ground water: United States Geological Survey, Techniques of Water Resource Investigations of the United States Geological Survey, Book 7, Chapter C2, 90 p.

Leahy, J.G., and Colewell, R.R., 1990, Microbial degradation of hydrocarbons in the environment: Microbiolgical Reviews, vol. 53, no. 3, p. 305-315.

Lee, M.D., 1988, Biorestoration of Aquifers Contaminated with Organic Compounds: CRC Critical Reviews in Environmental Control. vol. 18. p. 29-89.

Little, C.D., Palumbo, A.V., Herbes, S.E., Lidstrom, M.E., Tyndall, R.L., and Gilmer, P.J., 1988, Trichloroethylene biodegradation by a methane-oxidizing bacterium: Appl. Environ. Microbiol., vol. 54, no. 4, p. 951-956.

Lovley, D.R., and Phillips, E.J.P., 1988, Novel mode of microbial energy metabolism: organic carbon oxidation coupled to dissimilatory reduction of iron or manganese: Applied and Environmental Microbiology, v. 54, no. 6, p. 1472 - 1480.

Lovley, D.R., Phillips, E.J.P., and Lonergan, D.J., 1991, Enzymatic versus nonenzymatic mechanisms for Fe(III) reduction in aquatic sediments: Environmental Science and Technology, v. 26, no. 6, p. 1062 - 1067.

Lovely, D.R., Chappelle, F.H., and Woodward, J.C., 1994, Use of Dissolved H_2 Concentrations to Determine Distribution of Microbially Catalyzed Redox Reactions in Anoxic Groundwater: Environmental Science and Technology, v 28, no. 7, p. 1205-1210.

Lyman, W.J., Reidy, P.J., and Levy, B., 1992, Mobility and Degradation of Organic Contaminatns in Subsurface Environments: C.K. Smoley, Inc., Chelsea, Michigan, 395 p.

Mackay, D., and Wolkoff, A.W., 1973, Rate of Evaporation of Low-Solubility Contaminants from Water Bodies to Atmosphere: Environmental Science and Technology, vol. 7, no. 7, p. 611-614.

Mackay, D., and Shiu, W.Y., 1981, A Critical Review of Henry's Law Constants for Chemicals of Environmental Interest: Journal of Physical Chemistry Reference Data, vol. 10, no. 4, p. 1175-1199.

Malone, D.R., Kao, C.M., and Borden, R.C., 1993, Dissolution and biorestoration of nonaqueous phase hydrocarbons - models development and laboratory evaluation: Water Resources Research, vol. 29, no. 7, p. 2003-2213.

Mayer, K.P., Grbic-Galic, D., Semprini, L., and McCarty, P.L., 1988, Degradation of trichloroethylene by methanotrophic bacteria in a laboratory column of saturated aquifer material: Wat. Sci. Tech. (Great Britain), vol. 20, no. 11/12, p. 175-178.

McCarty, P.L., 1994, An Overview of Anaerobic Transformation of Chlorinated Solvents: In Symposium on Intrinsic Bioremediation in Ground Water. Denver, CO. August 30 - September 1, 1994, p. 135-142.

McCarty, P.L., Roberts, P.V., Reinhard, M., and Hopkins, G., 1992, Movement and transformations of halogenated aliphatic compounds in natural systems, In: Fate of Pesticides and Chemicals in the Environment. Ed., J.L. Schnoor. John Wiley & Sons, Inc. New York, New York. p. 191-209.

McCarty, P.L., and Semprini, L., 1994, Ground-Water Treatment for Chlorinated Solvents, In: Handbook of Bioremediation. Lewis Publishers, Boca Raton, FL. 1994.

Means, J.C., Wood, S.G., Hassett, J.J., and Banwart, W.L., 1980, Sorption of Polynuclear aromatic hydrocarbons by sediments and soils: Environmental Science and Technology, v. 14, no., 12, p. 1524-1528.

Miller, M.M., Wasik, S.P., Huang, G.L., Shiu, W.Y., and Mackay, D., 1985, Relationships Between Octanol-Water Partition Coefficient and Aqueous Solubility: Environmental Science and Technology, v. 19, no. 6, p. 522-529.

Miller, R.E., and Guengerich, F.P., 1982, Oxidation of trichloroethylene by liver microsomal cytochrome P-450: Evidence for chlorine migration in a transition state no involving trichloroethylene oxide: Biochemistry, vol. 21, p. 1090-1097.

Morell, F.M.M. and Hering, J.G., 1993, Principals and Applications of Aquatic Chemistry: John Wiley & Sons, Inc., New York.

Murray, W.D. and Richardson, M., 1993, Progress toward the biological treatment of C_1 and C_2 halogenated hydrocarbons: Critical Reviews in Environmental Science and Technology, v. 23, no. 3, p. 195-217.

Nelson, M.J.K., Montgomery, S.O., O'Neille, E.J., and Pritchard, P.H., 1986, Aerobic metabolism of trichloroethylene by a bacterial isolate: Appl. Environ. Microbiol., vol. 52, no. 2, p. 949-954.

Norris, R.D., Hinchee, R.E., Brown, R., McCarty, P.L. Semprini, L., Wilson, J.T., Kampbell, D.H., Reinhard, M., Bouwer, E.J., Borden, R.C., Vogel, T.M., Thomas, J.M., and Ward, C.H., 1994 Handbook of Bioremediation: Lewis Publishers, Inc., 257 p.

O'Brien and Gere Engineers, Inc. (OB&G), 1997, Phase II Investigation Zone 1 Site (SS-16, SS-19, WP-15). February.

OB&G, 1993, Installation Restoration Program, Health and Safety plan; Site FT-03 "Christmas Tree" Fire Training Area, Site FT-08 Current Fire Training Area, SS-19 Aqua Systems Site, SS-16 Hangar Apron Area, April.

OB&G, 1994a, Installation Restoration Program, Long Term Groundwater Monitoring Program, Interim Report, Sampling Round 1, January.

OB&G, 1994b, Installation Restoration Program, Long Term Groundwater Monitoring Program, Sampling Round 2, April.

OB&G, 1995a, Long Term Groundwater Monitoring Program Site SS-16 Hanger Apron Area, Sampling Rounds 3 and 4, February.

OB&G, 1995b, Remedial Investigation SS-19, Aqua Systems Site, May.

OB&G, 1996, Groundwater Sampling Program, Zone 1, Sites SS-16, SS-19, and WP-15, March.

Pankow, J.F., and Rosen, M.E., 1988, Determination of Volatile Compounds in Water by Purging Directly to an Capillary Column with Whole Column Cryotrapping: Environmental Science and Technology, vol. 22, no. 4, p. 398-405.

Parsons Engineering Science, Inc. (Parsons ES), 1996, Work Plan for a Treatability Study in Support of the Remediation by Natural Attenuation Option at Zone 1, Westover ARB, August.

Parsons ES, 1995, Work Plan for a Treatability Study in Support of Intrinsic Remediation at The Current Fire Training Area (FT-08) and The Christmas Tree Fire Training Area (FT-03), Westover Air Reserve Base, April.

Parsons ES, 1994, Interim Test Results Report for USTs Located at Building 7705, Westover ARB, December.

Perry, J.J., 1984, Microbial metabolism of cyclic alkanes, In, Petroleum Microbiology. R.M. Atlas, editor, Macmillan Publishing Co., New York, p. 61-67.

Reinhard, M., Goodman, N.L., and Barker, J.F., 1984, Occurrence and distribution of organic chemicals in two landfill leachate plumes: Environ. Sci. Technol., vol. 18, no. 12, p. 953-961.

Ribbons, D.W., and Eaton, R.W., 1992, Chemical Transformations of aromatic Hydrocarbons that Support the Growth of Microorganisms, In: Mitchell, R., ed.: Environmental Microbiology. Wiley-Liss, New York, NY.

Rifai, H.S., Bedient, P.B., Wilson, J.T., Miller, K.M., and Armstrong, J.M., 1988, Biodegradation modeling at aviation fuel spill site: Journal of Environmental Engineering, vol. 114, no. 5, p. 1007-1029.

Smith, J.H., Harper, J.C., and Jaber, H., 1981, Analysis and environmental fate of Air Force distillate and high density fuels: Report No. ESL-TR-81-54, Tyndall Air Force Base, Florida, Engineering and Services Laboratory.

Stauffer, T.B., Antworth, T.B., Boggs, J.M., and MacIntyre, W.G., 1994, A Natural Gradient Tracer Experiment in a Heterogeneous Aquifer with Measured In Situ Biodegradation Rates: A Case for Natural Attenuation, *in* Proceedings of the Symposium on Intrinsic Bioremediation of Ground Water, August 30 - September 1, 1994: US Environmental Protection Agency, p. 73 - 84.

Stumm, W. and Morgan, J.J., 1981, Aquatic Chemistry. John Wiley & Sons, New York, NY.

Thierrin, J., Davis, G.B., Barber, C., Patterson, B.M., Pribac, F., Power, T.R., and Lambert, M., 1992, Natural degradation rates of BTEX compounds and naphthalene in a sulfate-reducing ground water environment, In: In-Situ Bioremediation Symposium "92". Niagara-on-the-Lake, Ontario, Canada. September 20-24, 1992: In Press.

Thomas, G.M., 1987, Sedimentation in a Proglacial Lake: Glacial Lake Hitchcock, Rutgers University.

Tsien, H.-C., Brusseau, G.A., Hanson, R.S., and Wacket, L.P., 1989, Biodegradation of trichloroethylene by *Methylosinus trichosporium* OB3b: Appl. Environ. Microbiol., vol. 55, no. 12, p. 3155-3161.

UNC Geotech, 1991, Final Remedial Investigations Report, prepared for 439th Military Airlift Wing.

UNC Geotech, 1988, Remedial Investigations/Feasibility Studies Work Plan, prepared for 439th Military Airlift Wing.

US Geological Survey (USGS), 1979, 7.5 Minute Quadrangle Map of the Springfield North Quadrangle, Massachusetts

USGS, 1973a, USGS 1973b, USGS 1986a, USGS 1986b, 7.5 Minute Quadrangle Map of the Deep Creek Quandrangle, Washington, D.C.

US Environmental Protection Agency (USEPA), 1993, Revisions to the OMB Circular A-94 on Guidelines and Discount Rates for Benefit Cost Analysis, OSWER Directive 9355.3-20. June.

Valsaraj, K.T., 1988, On the Physio-Chemical Aspects of Partitioning of Non-Polar Hydrophobic Organics at the Air-Water Interface: Chemosphere, vol. 17, no. 5, p. 875-887.

van Genuchten, M.T. and Alves, W.J., 1982, Analytical Solutions of the One-Dimensional Convective-Dispersive Solute Transport Equation: US Department of Agriculture, Technical Bulletin Number 1661, 151p.

Verschueren, K., 1983, Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York, New York.

Vogel, T.M. and McCarty, P.L., 1985, Biotransformation of Tetrachloroethylene to Trichloroethylene, Dichloroethylene, Vinyl Chloride, and Carbon Dioxide Under Methanogenic Conditions. Appl. Environ. Microbiol. 49:1080-1083.

Vogel, T.M., Criddle, C.S. and McCarty, P.L., 1987, Transformations of halogenated aliphatic compounds: Environmental Science and Technology, v. 21, no. 8, p. 722-736.

Vogel, T.M., 1994, Natural Bioremediation of Chlorinated Solvents, In: Handbook of Bioremediation. Lewis Publishers, Boca Raton, FL. 1994.

Vroblesky, D.A., and Chapelle, F.H., 1994, Temporal and spatial changes of terminal electron-accepting processes in a petroleum hydrocarbon-contaminated aquifer and the significance for contaminant biodegradation: Water Resources Research, v. 30, no. 5, p. 1561-1570.

Walton, W.C., 1988, Practical Aspects of Ground Water Modeling. National Water Well Association, Worthington, Ohio, 587 p.

Weston 1984, Installation Restoration Program Final Report Phase II - Problem Confirmation Study, Westover Air Force Base, May 1984.

Westover Air Force Base. 1993. The Westover 2000 Plan, p. 10, 17-18.

Wexler, E.J. 1992, Analytical solutions for one-, two-, and three-dimensional solute transport in ground-water systems with uniform flow: United States Geological Survey, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 3, Chapter B7, 190 p.

Wiedemeier, Todd H., Downey, Douglas C., Wilson, John T., Kampbell, Donald H., Miller, Ross N., and Hansen, Jerry E., 1995, *Technical Protocol for Implementing the Intrinsic Remediation with Long-term Monitoring for Fuel Contamination Dissolved in Groundwater.* Prepared by the Air Force Center for Environmental Excellence.

Wilson, J.T., 1996, Personal communication between John Wilson of the USEPA NRMRL and Todd Wiedemeier of Parsons ES regarding USEPA definition of the term "natural attenuation", citing USEPA guidance undergoing internal review.

Wilson, J.T., and Wilson, B.H., 1985, Biotransformation of trichloroethylene in soil: Appl. Environ. Microbiol., vol. 49, no. 1, p. 242-243.

Wilson, B.H., Smith, G.B., and Rees, J.F., 1986, Biotransformations of selected alkylbenzenes and halogenated aliphatic hydrocarbons in methanogenic aquifer material: A microcosm study: Environmental Science and Technology, v. 20(10):997-1002.

Wilson, B.H., Bledsoe, B., and Kampbell, D., 1987, Biological processes occurring at an aviation gasoline spill site, In: R.C. Averett and D.M. McKnight editors, Chemical Quality of Water and the Hydrologic Cycle. Lewis Publishers, Chelsea, Michigan, p.125-137.

Wilson, B.H., Wilson, J.T., Kampbell, D.H., Bledsoe, B.E., and Armstrong, J.M., 1990, Biotransformation of Monoaromatic and Chlorinated Hydrocarbons at an Aviation Gasoline Spill Site: Geomicrobiology Journal, 8:225-240.

Wilson, B.H., Wilson, J.T., Kampbell, D.H., and Bledsoe, B.E., 1994, Traverse City: Geochemistry and Intrinsic Bioremediation of BTEX Compounds, In: Proceedings of the Symposium on Intrinsic Bioremediation of Ground Water. August 30 - September 1, 1994. US Environmental Protection Agency, p. 94 - 102.

Young, L.Y., 1984, Anaerobic degradation of aromatic compounds, In: Gibson, D.R., ed.: Microbial Degradation of Aromatic Compounds. Marcel-Dekker, New York.

APPENDIX A

GEOPROBE® BOREHOLE LOGS, MONITORING POINT CONSTRUCTION DIAGRAMS, SLUG TEST RESULTS

GEOLOGIC BORING LOG

BORING NO.:	MP-1$	CONTRACTOR:	Parsons ES	DATE SPUD:	9/10/96
CLIENT:	AFCEE	RIG TYPE:	Geoprobe	DATE CMPL.:	9/10/96
JOB NO.:	722450.28	DRLG METHOD:	Direct Push	ELEVATION:	
LOCATION:	WESTOVER ARB	BORING DIA.:	2"	TEMP:	85°
GEOLOGIST:	M.V.	DRLG FLUID:	None	WEATHER:	Cloudy
COMMENTS:					

Elev (ft)	Depth (ft)	Profile	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	WKSPC PID(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
8"	1	8"		Blk, Fine to MED SAND, roots								
				tan, medium grained sand, well sorted, no odor, dry	90%							
									0.0			
					4							
	5											
					80%							
				SAA, no odor, some coarse sand 2 1/4"					0.0			
					8							
	10											
					80%							
				SAA	12				0.0			
	15			SAA	80%		15'		0.0			
15.5		▼		wet at 16, no gravels	16		BTEX	TOC	0.0			
	20			TOTAL DEPTH 20'								
	25											
	30											
	35											

NOTES
- bgs – Below Ground Surface
- GS – Ground Surface
- TOC – Top of Casing
- NS – Not Sampled
- SAA – Same As Above

SAMPLE TYPE
- D – DRIVE
- C – CORE
- G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

BORING NO.:	~~SS-1~~ MP-2	CONTRACTOR:	Parsons ES	DATE SPUD:	9/10/96
CLIENT:	AFCEE	RIG TYPE:	Geoprobe	DATE CMPL.:	9/10/96
JOB NO.:	722450.28	DRLG METHOD:	Direct Push	ELEVATION:	
LOCATION:	WESTOVER ARB	BORING DIA.:	2"	TEMP:	65°
GEOLOGIST:	MV	DRLG FLUID:	none	WEATHER:	Cloudy
COMMENTS:					

Elev (ft)	Depth (ft)	Profile	USCS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID (ppm)	WKSPC PID (ppm)	TOTAL BTEX (ppm)	TPH (ppm)
10"				Black, F-M Sand, Some organics								
	1			Tan, Medium grained Sand dry, well sorted, little to ~~no~~ no clay or silt		90%						
						4			0.0			
	5											
				SAA		80%			0.0			
						8						
	10			Black from 11.5-11.8' no odor @ 12', TAN		75%			0.0			
									0.0			
						12 BTEX		14				
3.5		▼							0.0			
	15			Brown, SAA, wet, no odor, Some gravel <0.5"		90%			1.0			
						16						
				Refusal @ 16.5								
	20											
	25											
	30											
	35											

NOTES
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- GS – Ground Surface
- TOC – Top of Casing
- NS – Not Sampled
- SAA – Same As Above

SAMPLE TYPE
- D – DRIVE
- C – CORE
- G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

BORING NO.: MP-3 CONTRACTOR: Parsons ES DATE SPUD: 9/11/96
CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL.: 9/11/96
JOB NO.: 722450.28 DRLG METHOD: Direct Push ELEVATION:
LOCATION: WESTOVER ARB BORING DIA.: 2" TEMP: 65°-70°
GEOLOGIST: MJV DRLG FLUID: None WEATHER: Cloudy
COMMENTS:

Elev (ft)	Depth (ft)	Profile	USCS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID (ppm)	WKSPC PID (ppm)	TOTAL BTEX (ppm)	TPH (ppm)
16"	1			Black fine grained sand, organic								
				TAN Fine Sand, Dry		100%						
3.5'									0.3			
	5			medium, well sorted Fine Sand, Dry, no odor		4						
						90%			0.9			
				SAA, no odor		8						
	10											
				SAA, no odor		90%			0.0			
						12						
						88%						
	15			SAA		16	16.5 TOC		4.2			
									0.0			
						60%						
				SAA, slight odor		20			9.0			
	20			Bottom @ 20'								
	25											
	30											
	35											

NOTES
bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE
D – DRIVE
C – CORE
G – GRAB
▼ Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.:	MP-4	CONTRACTOR:	Parsons ES	DATE SPUD:	9/11/96
CLIENT:	AFCEE	RIG TYPE:	Geoprobe	DATE CMPL.:	9/11/96
JOB NO.:	722450.28	DRLG METHOD:	Direct Push	ELEVATION:	
LOCATION:	WESTOVER ARB	BORING DIA.:	2"	TEMP:	70°
GEOLOGIST:	MJV	DRLG FLUID:	None	WEATHER:	Cloudy
COMMENTS:					

Elev (ft)	Depth (ft)	Profile	USCS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	WKSPC PID(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
~6"				Blk F-sand w/ organics								
	1											
				med-coarse, fine sand gravel < 0.5", no odor dry		90%			0.0			
						4						
	5											
						90%						
				SAA, no odor		8			0.0			
	10											
				SAA		40%			~~1.8~~			
						12						
				SAA		80%			1.8			
15.5	15	▼		WET @ 15.5 no odor		16			0.3			
	20			BOTTOM @ 20								
	25											
	30											
	35											

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

BORING NO.: MP-5 CONTRACTOR: Parsons ES DATE SPUD: 9/11/96
CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL.: 9/11/96
JOB NO.: 722450.28 DRLG METHOD: Direct Push ELEVATION:
LOCATION: WESTOVER ARB BORING DIA.: 2" TEMP: 70°
GEOLOGIST: MJJ DRLG FLUID: None WEATHER: Cloudy
COMMENTS: Cave in from surface was making Geoprobe rods ~~[illegible]~~ difficult to pull out

Elev (ft)	Depth (ft)	Pro-file	USCS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	WKSPC PID(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
6"				F-M- Blk sand, w/ organics								
	1			med-coarse sand w/ gravel <0.5" dry, well sorted no odor		80%						
						4			0.0			
	5											
						80%						
				medium sand @ 8', no odor		8			0.0			
	10					100%						
				SAA, no odor gravel lense @ 12 Grey w/ some silt		12			0.0			
						80%						
						14			0.0			
	15			refusal @ 14' bgs								
	20											
	25											
	30											
	35											

NOTES
bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE
D – DRIVE
C – CORE
G – GRAB

Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

BORING NO.:	MP-6	CONTRACTOR:	PARSONS ES	DATE SPUD:	9/11/96
CLIENT:	AFCEE	RIG TYPE:	GEOPROBE	DATE CMPL.:	9/11/96
JOB NO.:	722450.28	DRLG METHOD:	DIRECT PUSH	ELEVATION:	
LOCATION:	WESTOVER ARB	BORING DIA.:	2"	TEMP:	70°
GEOLOGIST:	MJV	DRLG FLUID:	None	WEATHER:	Cloudy

COMMENTS: Formation Colapse prevented installation of Monitoring Point

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	WKSPC PID(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
-6"				Blk, m-Sand, organics								
	1			med-coarse, tan SAND Dry no odor		100%						
						4						
	5					100%						
				SAA, no odor		8						
	10			SAA, GRAVEL < 1.0"		100%						
						11						
				medium @ 15		90%						
	15			wet @ 15.5		15						
				SAA wet		80%						
						19						
	20											
	25											
	30											
	35											

NOTES
bgs — Below Ground Surface
GS — Ground Surface
TOC — Top of Casing
NS — Not Sampled
SAA — Same As Above

SAMPLE TYPE
D — DRIVE
C — CORE
G — GRAB

Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

BORING NO.: MP-7
CONTRACTOR: PARSONS ES
DATE SPUD: 9/12/96
CLIENT: AFCEE
RIG TYPE: GEOPROBE
DATE CMPL.: 9/12/96
JOB NO.: 722450.28
DRLG METHOD: DIRECT PUSH
ELEVATION:
LOCATION: WESTOVER ARB
BORING DIA.: 1"
TEMP: 70°
GEOLOGIST: MJV
DRLG FLUID: None
WEATHER: Cloudy
COMMENTS: poor Recovery - wet sand was falling out of the sampler during sample recovery

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID (ppm)	WKSPC PID (ppm)	TOTAL BTEX (ppm)	TPH (ppm)
	1											
	5											
	10											
	15											
	20											
	25											
	30											
	35			medium, wet sand, well sorted slight odor		34 603 36			0.6			

NOTES
bgs — Below Ground Surface
GS — Ground Surface
TOC — Top of Casing
NS — Not Sampled
SAA — Same As Above

SAMPLE TYPE
D — DRIVE
C — CORE
G — GRAB

Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.: MP-10 CONTRACTOR: PARSONS ES DATE SPUD: 7/13/96
CLIENT: AFCEE RIG TYPE: GEOPROBE DATE CMPL.: 9/13/96
JOB NO.: 722450.28 DRLG METHOD: DIRECT PUSH ELEVATION:
LOCATION: WESTOVER ARB BORING DIA.: 2" TEMP: 75°
GEOLOGIST: MJV DRLG FLUID: None WEATHER: Pc Cloudy
COMMENTS:

Elev (ft)	Depth (ft)	Profile	USCS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	WKSPC PID(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
12"	1			BK f-medium sand w/ organics								
				Tan medium sand, Dry no odor		100%						
						4			0.0			
	5			~~coarse~~ medium to coarse @ 5								
						90%						
				gravel @ 7' (< 1")		8			0.0			
	10					90%						
				m-c sand		12			0.0			
						90%						
	15			SAA		16			0.0			
						90%						
	20			SAA, no odor, some Horizontal iron staining		20	21' TOC		0.0			
21"		▽				90%						
				SAA		24			0.0			
	25			Bottom @ 24' bgs								
	30											
	35											

NOTES
bgs — Below Ground Surface
GS — Ground Surface
TOC — Top of Casing
NS — Not Sampled
SAA — Same As Above

SAMPLE TYPE
D — DRIVE
C — CORE
G — GRAB

▼ Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

BORING NO.: MP-11 CONTRACTOR: PARSONS ES DATE SPUD: 9/4/96
CLIENT: AFCEE RIG TYPE: GEOPROBE DATE CMPL.: 9/4/96
JOB NO.: 722450.28 DRLG METHOD: DIRECT PUSH ELEVATION:
LOCATION: WESTOVER ARB BORING DIA.: 2.0" TEMP: 75°
GEOLOGIST: MRV DRLG FLUID: NONE WEATHER: P. Cloudy
COMMENTS:

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	WKSPC PID(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
8"	1			Fm-Blk sand w/ organics								
				fine-medium brown sand (fill)		100%						
						4						
	5					90%						
				SAA		7						
						90%						
				SAA								
	10					10						
				med-coarse sand, tan dry, no odor		100%						
						14						
	15			coarse & gravel <1.5" @ 15'		90						
17				med @ 16		17	TOC @ 16.5 17.0					
				sand, no gravel		90						
	20			Bottom @ 20' bgs		20						
	25											
	30											
	35											

NOTES
bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE
D – DRIVE
C – CORE
G – GRAB

Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

BORING NO.:	MP-14	CONTRACTOR:	Parsons ES	DATE SPUD:	9/14/96
CLIENT:	AFCEE	RIG TYPE:	Geoprobe	DATE CMPL.:	9/14/96
JOB NO.:	722450.28	DRLG METHOD:	Direct Push	ELEVATION:	
LOCATION:	WESTOVER ARB	BORING DIA.:	2.0"	TEMP:	75°
GEOLOGIST:	MJV	DRLG FLUID:	None	WEATHER:	P. Cloudy

COMMENTS:

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	WKSPC PID(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
6"				Blk f-m sand w/ organics								
	1			m-c sand, tan dry no odor		100%						
						4			0.0			
	5					90%						
				SAA, no odor		8			1.6			
	10					90%						
				SAA, dry no odor		12			10.4			
						90%						
	15			moist, no odor @ 15			BTEX	@	20.0			
16				wet, strong fuel odor @ 16', medium sand, no gravel		16	TOC	16.5	401			
						70%						
	20					20						
				Bottom @ 20' bgs								
	25											
	30											
	35											

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of 1

BORING NO.:	~~[illegible]~~ SS1	CONTRACTOR:	PARSONS ES	DATE SPUD:	9/11/96
CLIENT:	AFCEE	RIG TYPE:	GEOPROBE	DATE CMPL.:	9/11/96
JOB NO.:	722450.28	DRLG METHOD:	DIRECT PUSH	ELEVATION:	
LOCATION:	WESTOVER ARB	BORING DIA.:	2"	TEMP:	70°
GEOLOGIST:	MJV	DRLG FLUID:	None	WEATHER:	Cloudy
COMMENTS:					

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	WKSPC PID(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
-1.5'	1			Blk, m-c sand, organic matter dry								
				tan, m-c sand, dry no odor		90%						
						4						
	5					90%						
				SAA, coarse		8			0.0			
	10					90%						
				SAA, no odor		12			0.0			
						80%						
▼	15			wet @ 15			BTEX TOC		0.8			
				Bottom @ 16		16						
	20											
	25											
	30											
	35											

NOTES

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GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of

BORING NO.:	SS-2	CONTRACTOR:	ParsonsES	DATE SPUD:	9/15/96
CLIENT:	AFCEE	RIG TYPE:	Geoprobe	DATE CMPL.:	9/15/96
JOB NO.:	729691.28	DRLG METHOD:	Geoprobe	ELEVATION:	
LOCATION:	Westover	BORING DIA.:	2.0"	TEMP:	75°
GEOLOGIST:	MJV	DRLG FLUID:	None	WEATHER:	P. Cloudy

COMENTS:

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	TLV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
				m-c sand, some gravel <1.0", dry, no odor		100%						
									0.6			
	5					4						
				SAA		100%						
									32.0			
						8						
	10					98%			3.9			
				m-c sand, some gravel, moist, no odor								
						12	BTEX & TOC	13.5'	20.4			
▼ 13.5				wet and fuel Stained @ 13.5		90%		104	~~50.5~~			
									43.5			
	15					15			325			
				Bottom @ 15' bgs								

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG

ENGINEERING-SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of

BORING NO.: SS-3 CONTRACTOR: Parsons ES DATE SPUD: 9/15/96
CLIENT: AFCEE RIG TYPE: GeoProbe DATE CMPL.: 9/15/96
JOB NO.: 729691.28 DRLG METHOD: Direct Push ELEVATION:
LOCATION: Westover BORING DIA.: 2" TEMP: 80°
GEOLOGIST: MJV DRLG FLUID: None WEATHER: P. Cloudy
COMENTS:

Elev (ft)	Depth (ft)	Pro-file	US CS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	TLV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
	1			~~Tan~~ Brown, M-C sand, some gravel, dry, no odor		100%						
						4			1.9			
	5											
				SAA		80%						
				@ 8'- Blk Staining slight odor ?		8	BTEX 8.5		45			
	10											
				Coarse, Sand w/ gravel @ 12', dry, no odor		90%			17			
						12	TOC 13		17			
	15			Bottom @ 15'		15'						

NOTES
bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE
D – DRIVE
C – CORE
G – GRAB

Water level drilled

GEOLOGIC BORING LOG

ENGINEERING-SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of

BORING NO.: SS-4 CONTRACTOR: Parsons ES DATE SPUD: 9/15/96
CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL.: 9/15/96
JOB NO.: 724691.28 DRLG METHOD: Direct Push ELEVATION:
LOCATION: Westover BORING DIA.: 2.0" TEMP: 80°
GEOLOGIST: MJV DRLG FLUID: None WEATHER: P. Cloudy
COMENTS:

Elev (ft)	Depth (ft)	Pro-file	USCS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	TLV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
				Brown - f-m sand, fill, soft, no odor		90%						
						4			0.9			
	5					90%						
				SAA		8			12.0			
	10			SAA		90%						
				TAN, m-c sand w gravel <1", moist no odor		12	13.0 14		6.0			
14						80%	BTEX TOC					
	15					15			13.0			
				Bottom @ 15' bgs								

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG

ENGINEERING-SCIENCE, INC.
Denver, Colorado

GEOLOGIC BORING LOG

Sheet 1 of

BORING NO.: SS-5 CONTRACTOR: Parsons DATE SPUD: 9/15/96
CLIENT: AFCEE RIG TYPE: Geoprobe DATE CMPL.: 9/15/96
JOB NO.: 729691 DRLG METHOD: Direct Push ELEVATION:
LOCATION: Westover BORING DIA.: 2.0" TEMP: 85°
GEOLOGIST: MJV DRLG FLUID: None WEATHER: P. Cloudy
COMENTS:

Elev (ft)	Depth (ft)	Profile	USCS	Geologic Description	Sample No.	Sample Depth (ft)	Sample Type	Penet Res	PID(ppm)	TLV(ppm)	TOTAL BTEX(ppm)	TPH (ppm)
1.5				med-sand, Blk, no odor								
				Brown, f-med Sand, moist ~~Slight~~ Moderate odor?		100% 3	4' BTEX		60.0			
5.5	5 5.5			med-c moist tan Sand Slight odor?		90% 7	7' BTEX		20.0			
						90% 11						
	10			SAA, no odor		90% 14						
▼				wet and Stained at 13'		14	12' BTEX		19.0			
	15			Bottom @ 14'								

NOTES
bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE
D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

GEOLOGIC BORING LOG

ENGINEERING-SCIENCE, INC.
Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-1

JOB NUMBER 722450.28 INSTALLATION DATE SEPT 10, 1996 LOCATION Zone 1

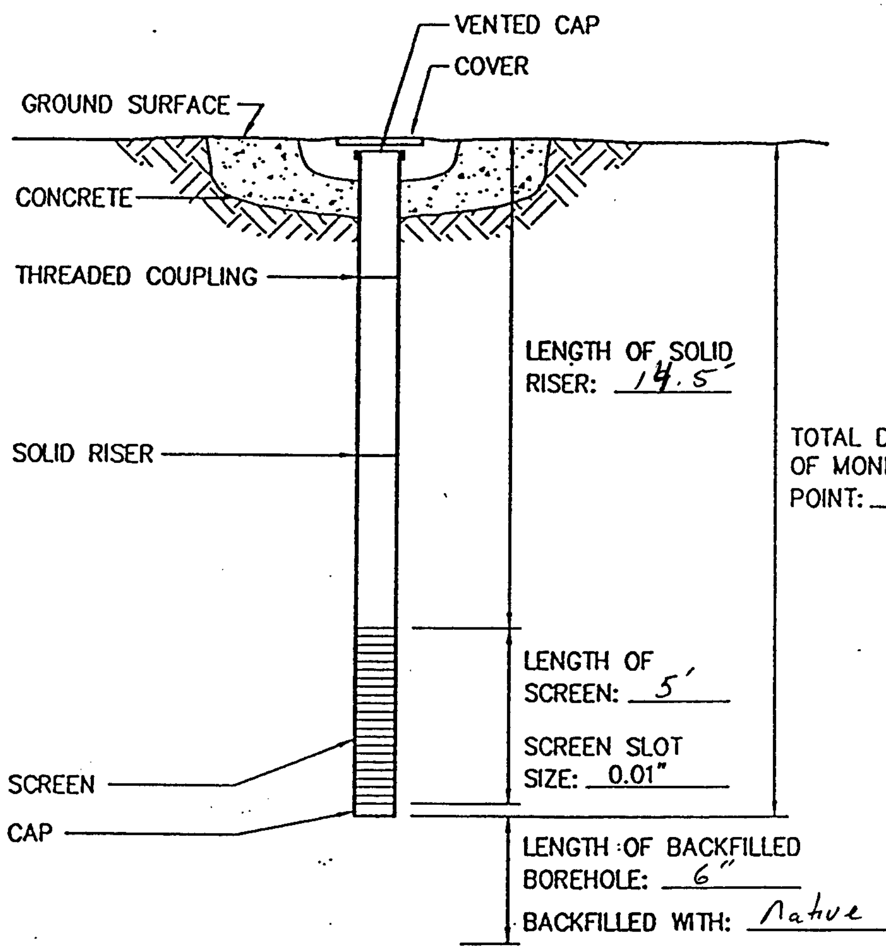
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT Top of Casing

SCREEN DIAMETER & MATERIAL 0.5" - PVC SLOT SIZE 0.010

RISER DIAMETER & MATERIAL 0.5" - PVC BOREHOLE DIAMETER 3"

CONE PENETROMETER CONTRACTOR Parsons ES ES REPRESENTATIVE MV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 19.5 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

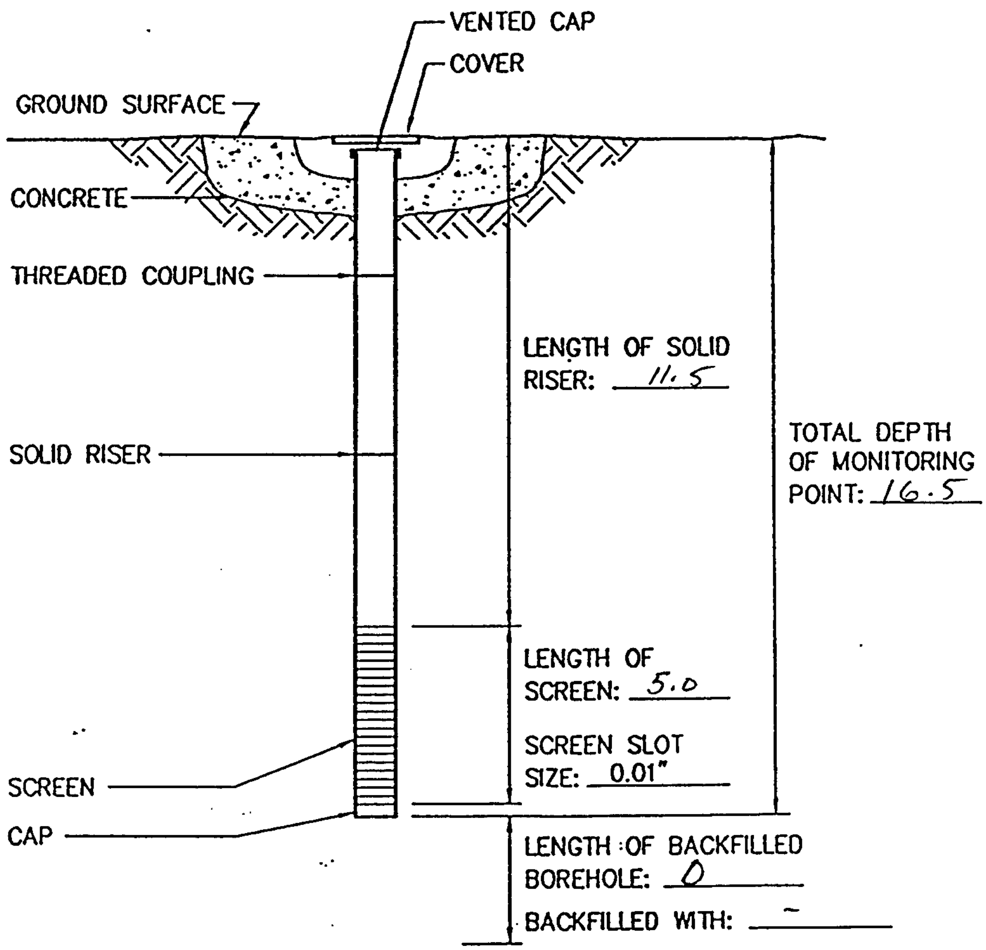
Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-2
JOB NUMBER 722450.28 INSTALLATION DATE SEPT 10, 1996 LOCATION ZONE 1
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______
DATUM FOR WATER LEVEL MEASUREMENT TOP OF CASING
SCREEN DIAMETER & MATERIAL 0.5" - PVC SLOT SIZE 0.010
RISER DIAMETER & MATERIAL 0.5" - PVC BOREHOLE DIAMETER 3"
CONE PENETROMETER CONTRACTOR PARSONS ES ES REPRESENTATIVE MV



(NOT TO SCALE)

STABILIZED WATER LEVEL 13.65 FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 16.5 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-3

JOB NUMBER 722450.28 INSTALLATION DATE SEPT 11, 1996 LOCATION ZONE 1

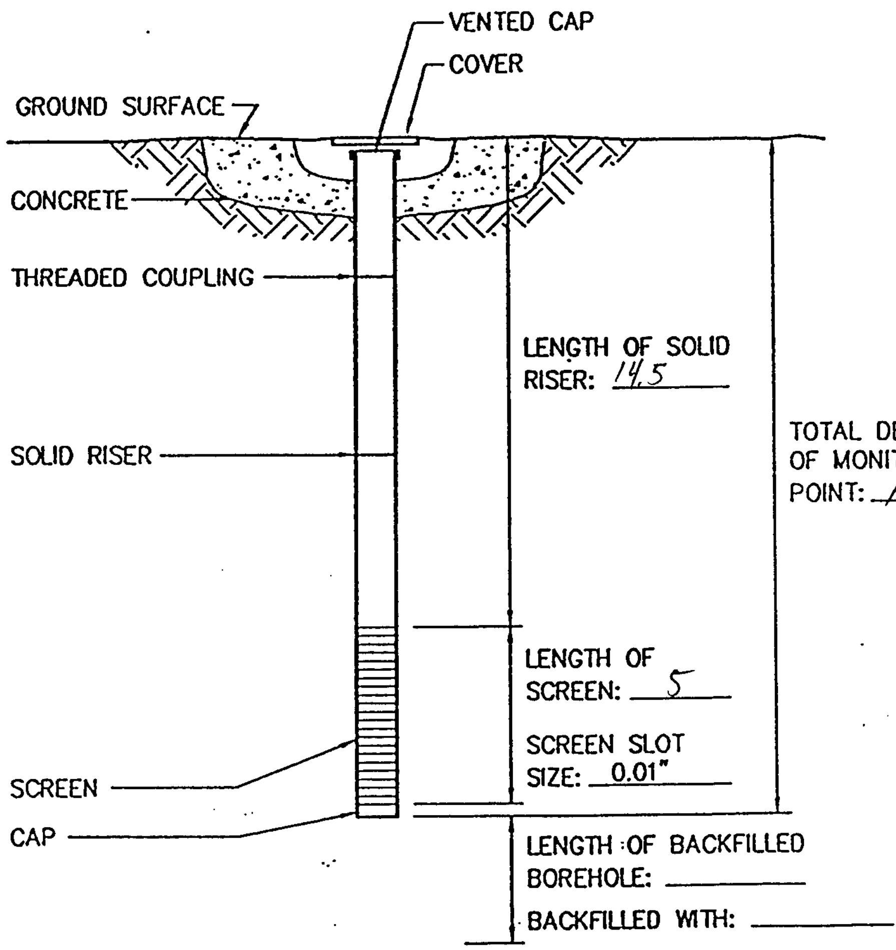
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT TOP OF CASING

SCREEN DIAMETER & MATERIAL 0.5" - PVC SLOT SIZE 0.010

RISER DIAMETER & MATERIAL 0.5" - PVC BOREHOLE DIAMETER ______

CONE PENETROMETER CONTRACTOR PARSONS ES ES REPRESENTATIVE MV



(NOT TO SCALE)

STABILIZED WATER LEVEL 17.0 FEET BELOW ~~DATUM~~. G.S.

TOTAL MONITORING POINT DEPTH ______ FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-4

JOB NUMBER 722450.28 INSTALLATION DATE SEPT 12, 1996 LOCATION ZONE 1

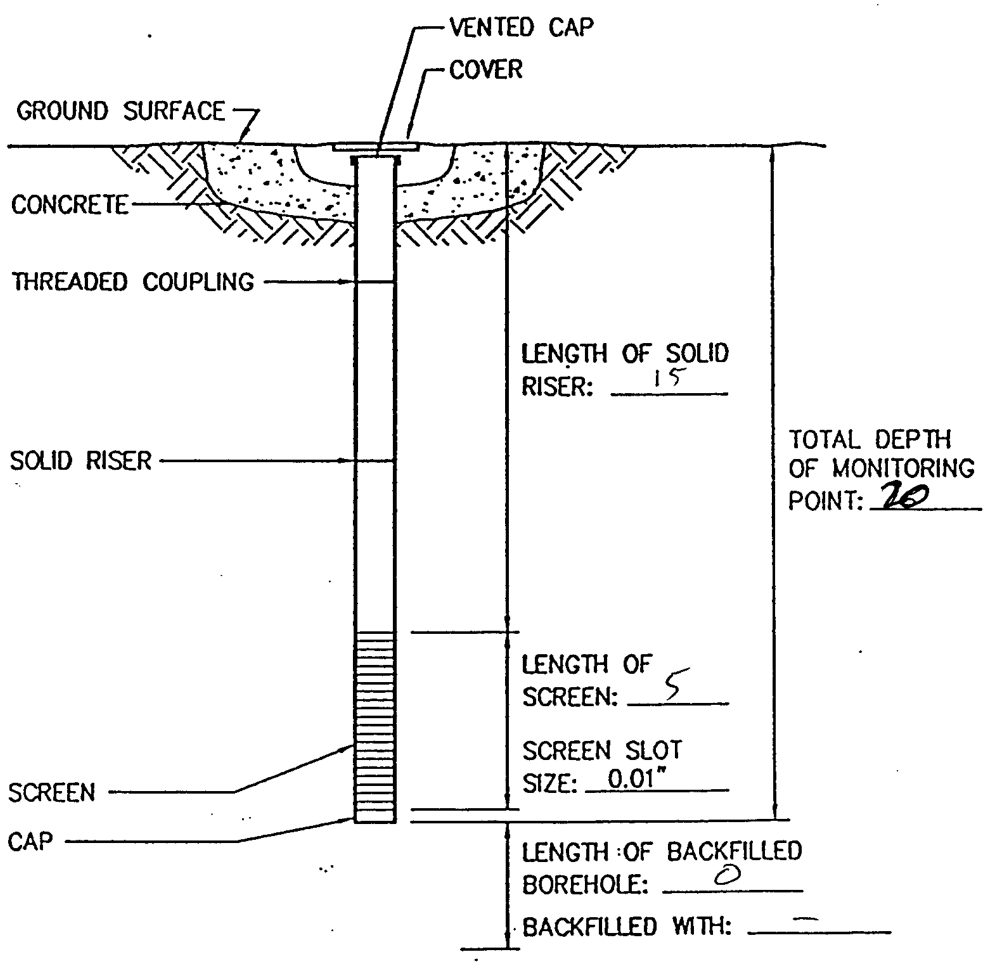
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT TOP OF CASING

SCREEN DIAMETER & MATERIAL 0.5" 2"mw - PVC SLOT SIZE 0.010

RISER DIAMETER & MATERIAL 0.5" 2" - PVC BOREHOLE DIAMETER 2"

CONE PENETROMETER CONTRACTOR Parsons ES ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 20 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-5(S)

JOB NUMBER 722450.28 INSTALLATION DATE SEPT 12, 1996 LOCATION ZONE 1

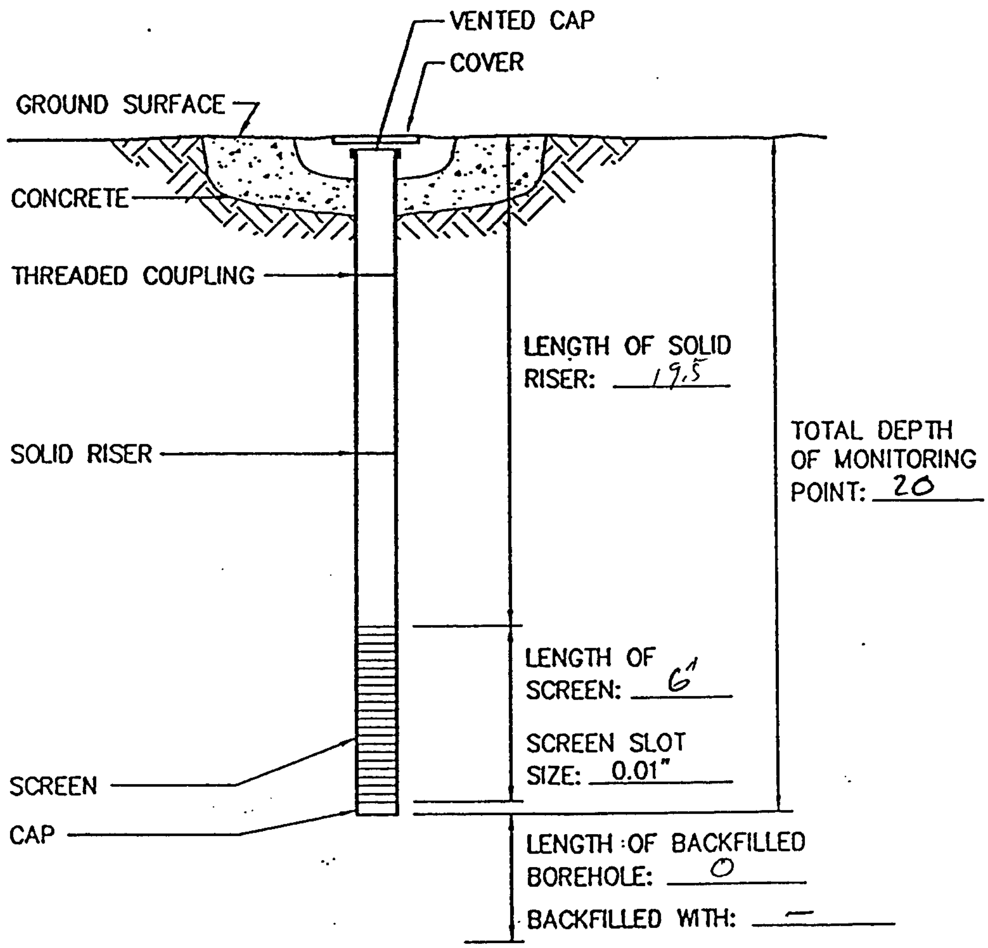
DATUM ELEVATION ________ GROUND SURFACE ELEVATION ________

DATUM FOR WATER LEVEL MEASUREMENT TOP OF CASING

SCREEN DIAMETER & MATERIAL 0.5" - PVC SLOT SIZE 0.010

RISER DIAMETER & MATERIAL 0.5" - PVC BOREHOLE DIAMETER 2"

CONE PENETROMETER CONTRACTOR PARSONS ES ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ________ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 20 FEET BELOW DATUM.

GROUND SURFACE ________ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-5(D)

JOB NUMBER 722450.28 INSTALLATION DATE Sept 12, 1996 LOCATION Zone 1

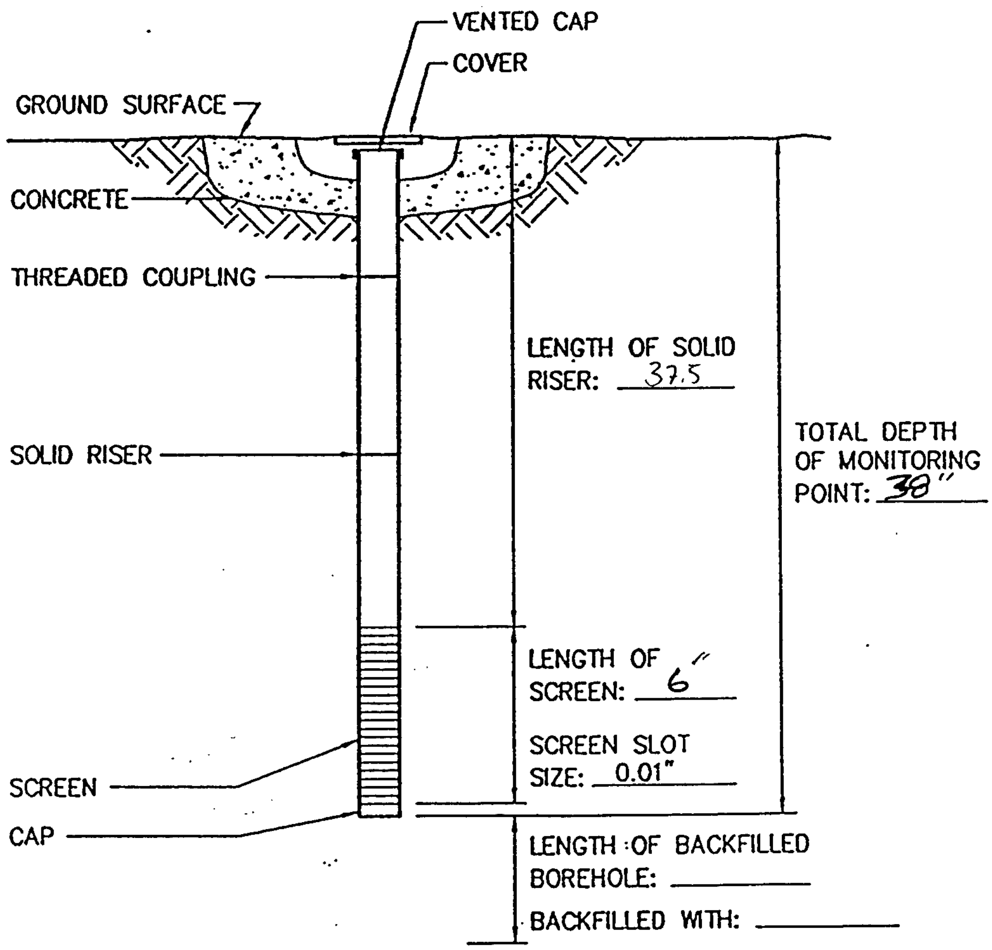
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT – Not Applicable

SCREEN DIAMETER & MATERIAL 0.375" - Stainless steel SLOT SIZE 0.010

RISER DIAMETER & MATERIAL 0.375" – HDPE BOREHOLE DIAMETER 0.5"

CONE PENETROMETER CONTRACTOR Parsons ES ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 38 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-6

JOB NUMBER 722450.28 INSTALLATION DATE SEPT 11, 1996 LOCATION ZONE 1

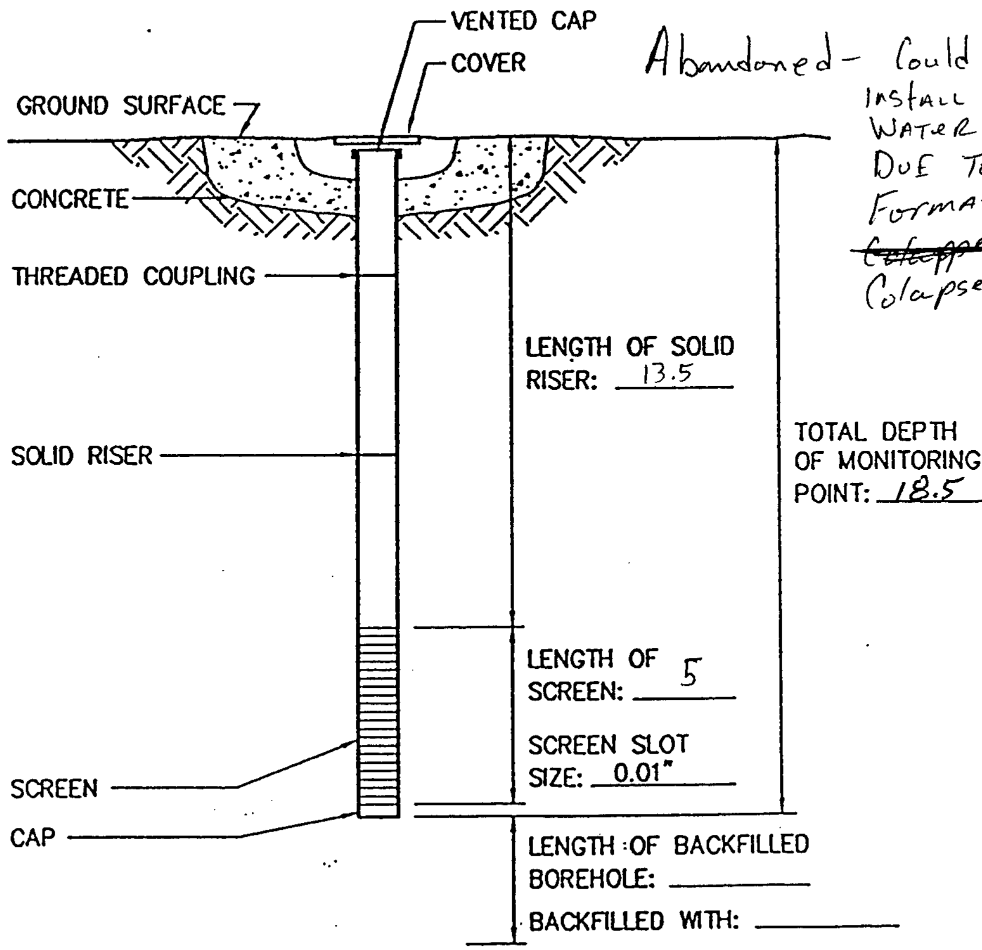
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT –

SCREEN DIAMETER & MATERIAL – SLOT SIZE –

RISER DIAMETER & MATERIAL – BOREHOLE DIAMETER 2"

CONE PENETROMETER CONTRACTOR PARSONS ES ES REPRESENTATIVE MJV



Abandoned - Could not install Below Water Table Due To Formation ~~Colapse~~ Colapse.

(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH ______ FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB — MONITORING POINT NUMBER MP-7

JOB NUMBER 722450.28 — INSTALLATION DATE Sept 12, 1996 — LOCATION Zone 1

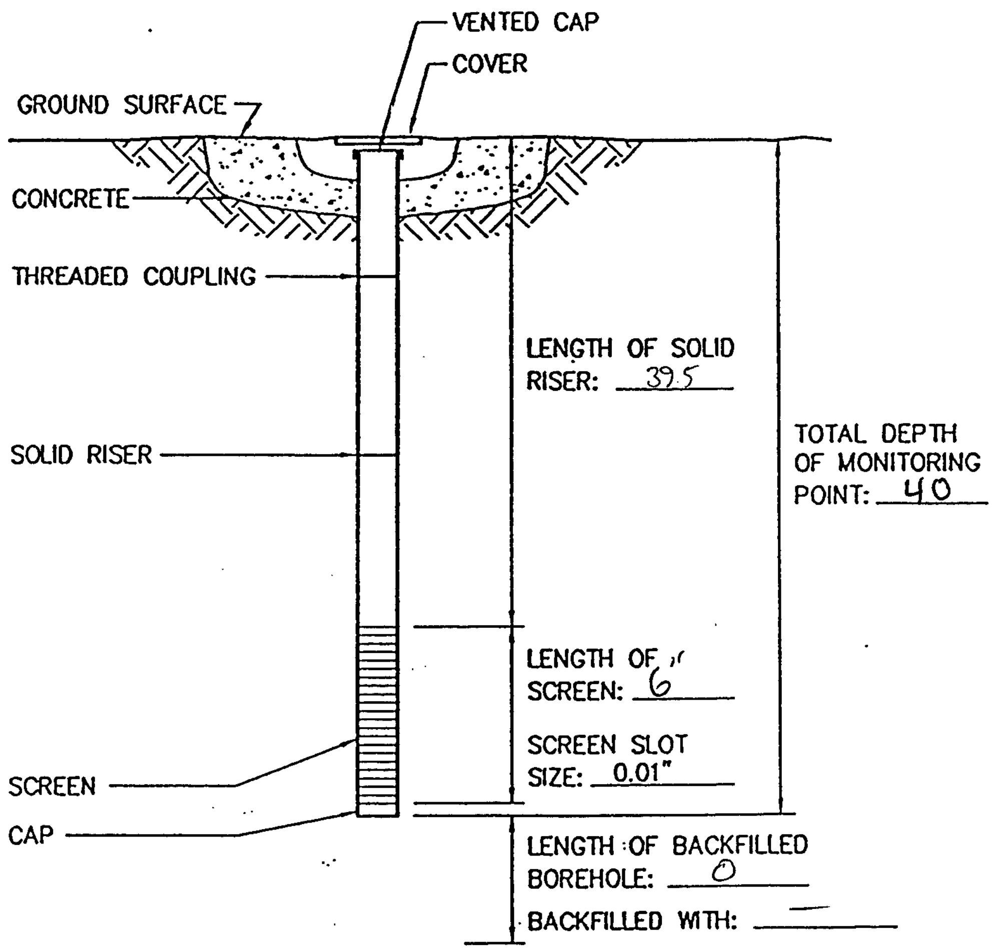
DATUM ELEVATION ______ — GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT NA

SCREEN DIAMETER & MATERIAL 0.375" - Stainless — SLOT SIZE 0.01

RISER DIAMETER & MATERIAL 0.375" - HDPE — BOREHOLE DIAMETER 1.0 inches

CONE PENETROMETER CONTRACTOR PARSONS ES — ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 40 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-8

JOB NUMBER 722450.28 INSTALLATION DATE Sept 12, 1996 LOCATION Zone 1

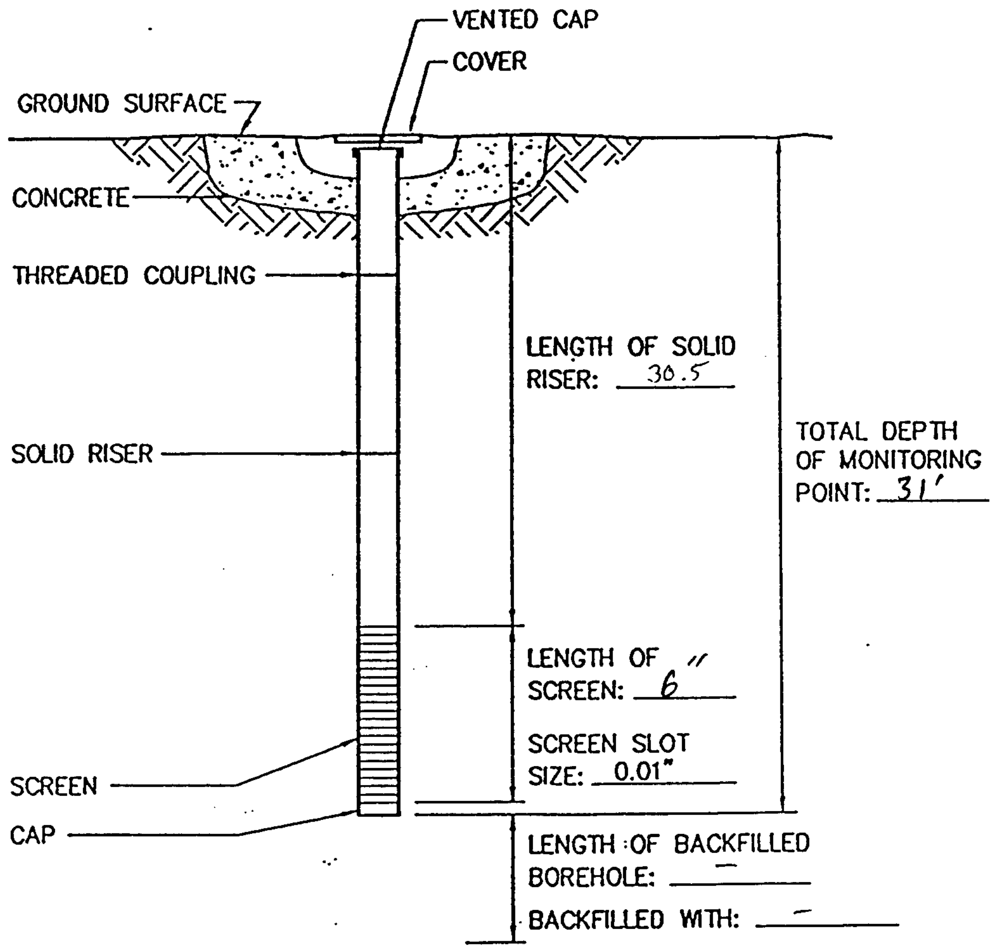
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT NA

SCREEN DIAMETER & MATERIAL 0.375" - Stainless SLOT SIZE 0.010"

RISER DIAMETER & MATERIAL 0.375" - HDPE BOREHOLE DIAMETER 1.0"

CONE PENETROMETER CONTRACTOR Parsons ES ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 31 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME: WESTOVER ARB — MONITORING POINT NUMBER: MP-9

JOB NUMBER: 722450.28 — INSTALLATION DATE: SEPT 12, 1996 — LOCATION: Zone 1

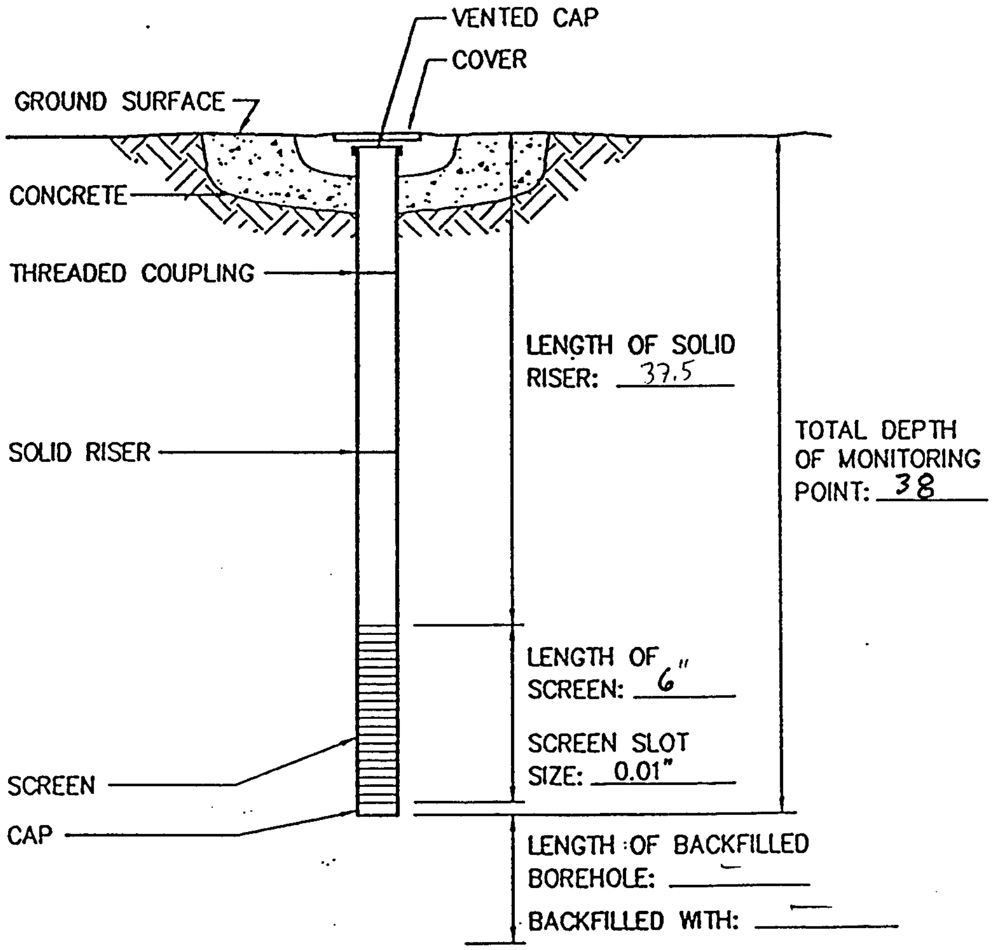
DATUM ELEVATION: ______ — GROUND SURFACE ELEVATION: ______

DATUM FOR WATER LEVEL MEASUREMENT: NA

SCREEN DIAMETER & MATERIAL: 0.375" - Stainless — SLOT SIZE: 0.010

RISER DIAMETER & MATERIAL: 0.375" - PVC — BOREHOLE DIAMETER: 1.0"

CONE PENETROMETER CONTRACTOR: Parsons ES — ES REPRESENTATIVE: MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 38 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-10

JOB NUMBER 722450.28 INSTALLATION DATE Sept , 1996 LOCATION Zone 1

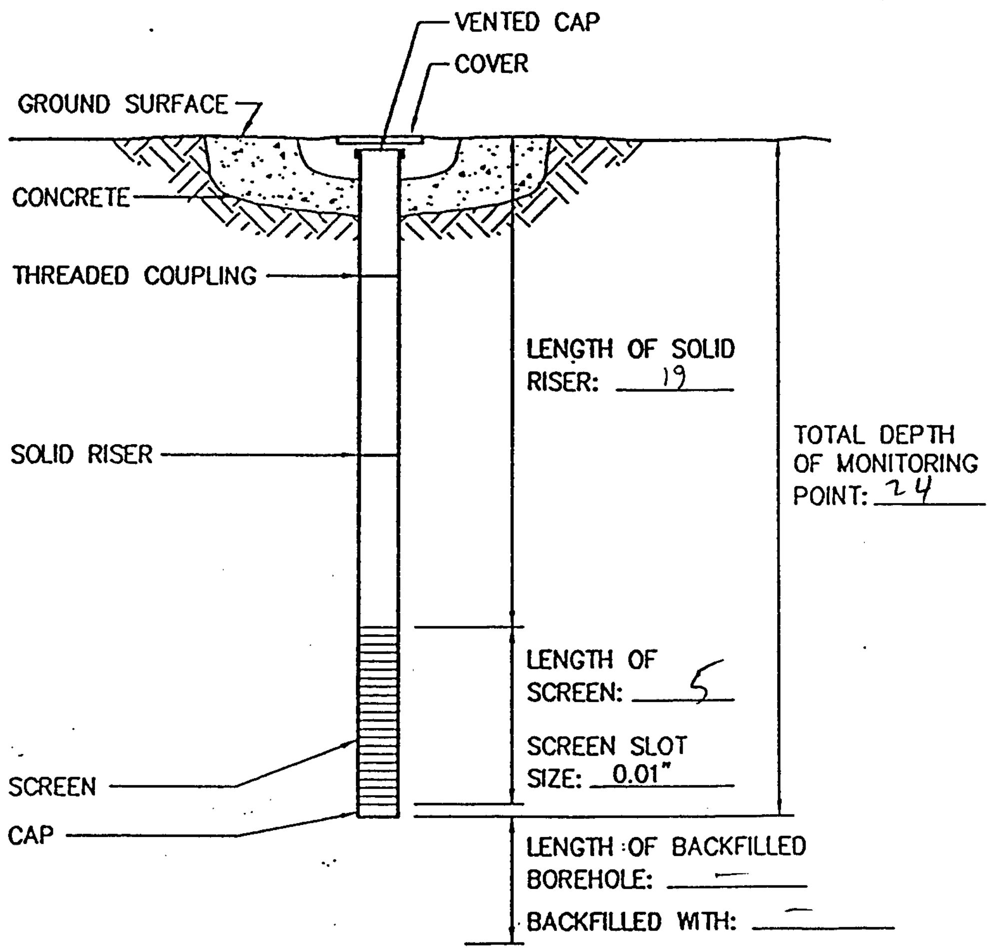
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT Top of Casing

SCREEN DIAMETER & MATERIAL 0.5" - PVC SLOT SIZE ~~0.02~~ 0.010

RISER DIAMETER & MATERIAL 0.5" - PVC BOREHOLE DIAMETER 2.0"

CONE PENETROMETER CONTRACTOR Parsons ES ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 24 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1

Remediation By Natural Attenuation TS

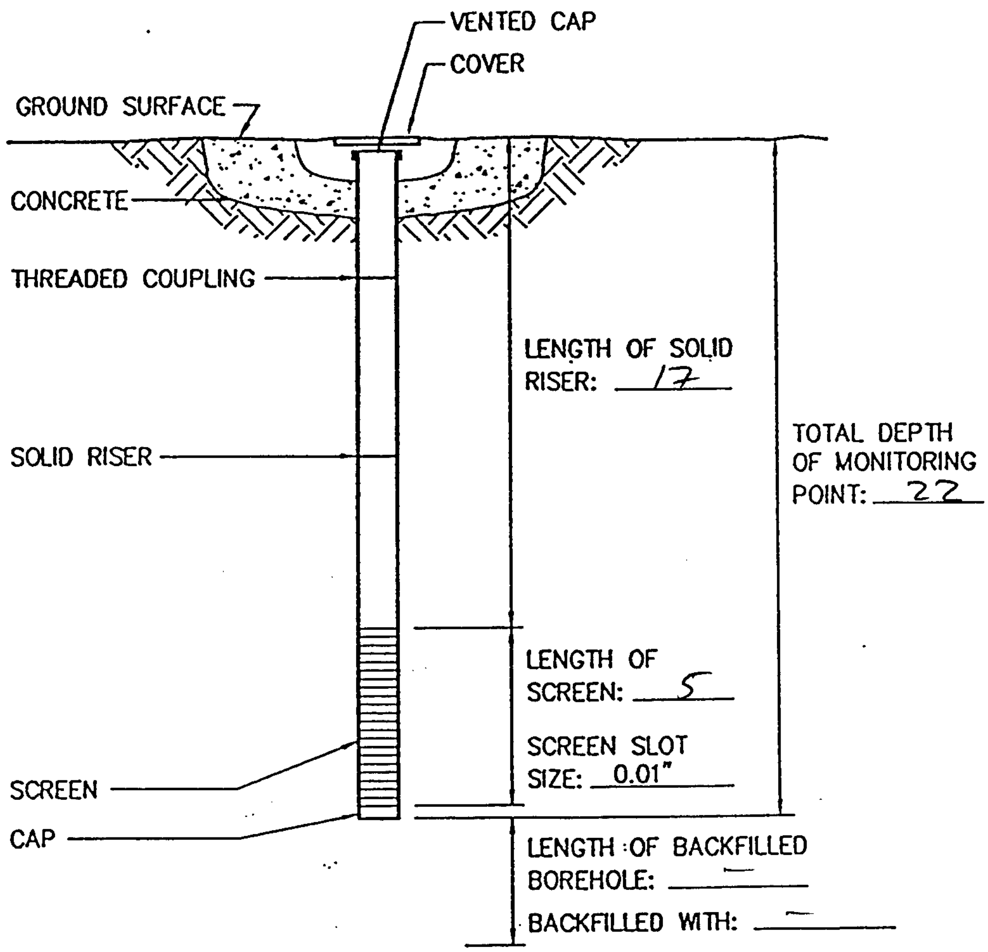
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME: WESTOVER ARB
MONITORING POINT NUMBER: MP-11S
JOB NUMBER: 722450.28
INSTALLATION DATE: Sept 14, 1996
LOCATION: Zone 1
DATUM ELEVATION:
GROUND SURFACE ELEVATION:
DATUM FOR WATER LEVEL MEASUREMENT: Top of Casing
SCREEN DIAMETER & MATERIAL: 0.5" - PVC
SLOT SIZE: 0.010
RISER DIAMETER & MATERIAL: 0.5" - PVC
BOREHOLE DIAMETER: 2"
CONE PENETROMETER CONTRACTOR: Parsons ES
ES REPRESENTATIVE: MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ____ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 22 FEET BELOW DATUM.

GROUND SURFACE ____ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER 11(D)

JOB NUMBER 722450.28 INSTALLATION DATE Sept 12, 1996 LOCATION Zone 1

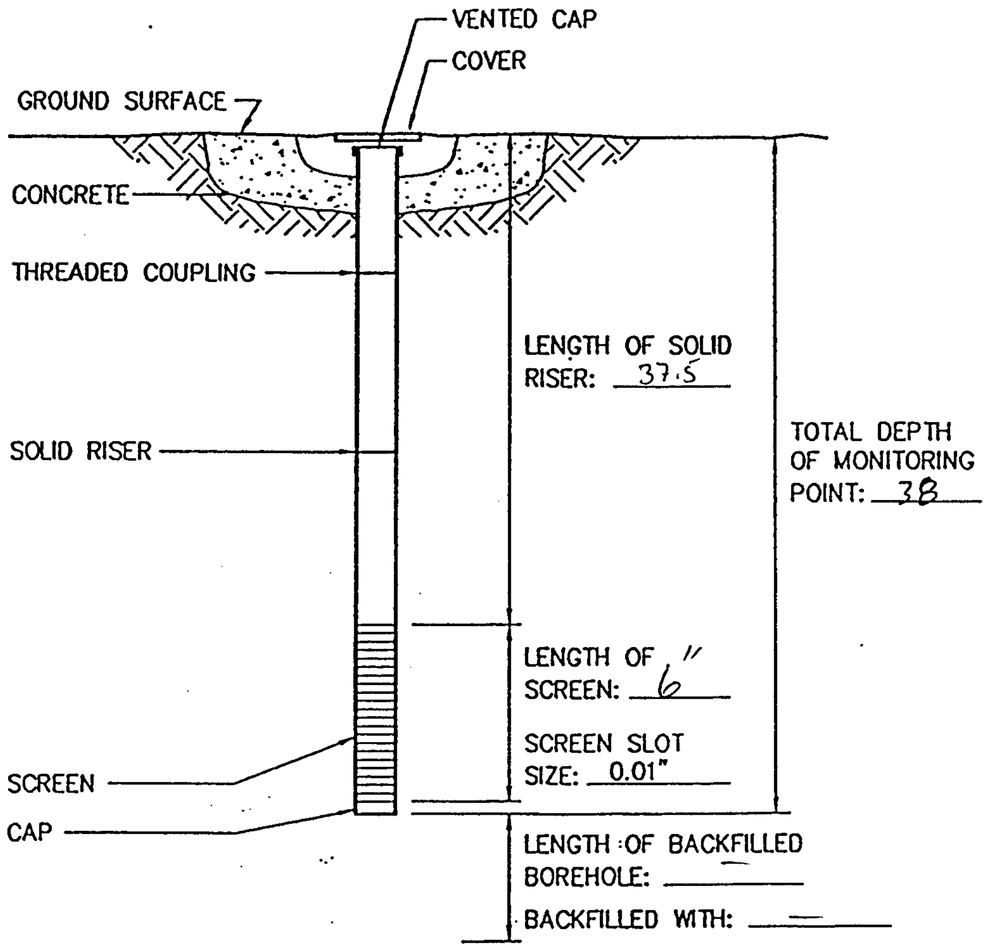
DATUM ELEVATION ________ GROUND SURFACE ELEVATION ________

DATUM FOR WATER LEVEL MEASUREMENT NA

SCREEN DIAMETER & MATERIAL 0.375 - Stainless SLOT SIZE 0.010

RISER DIAMETER & MATERIAL 0.375- HDPE BOREHOLE DIAMETER 1.0"

CONE PENETROMETER CONTRACTOR Parsons ES ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ________ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 38 FEET BELOW DATUM.

GROUND SURFACE ________ FEET

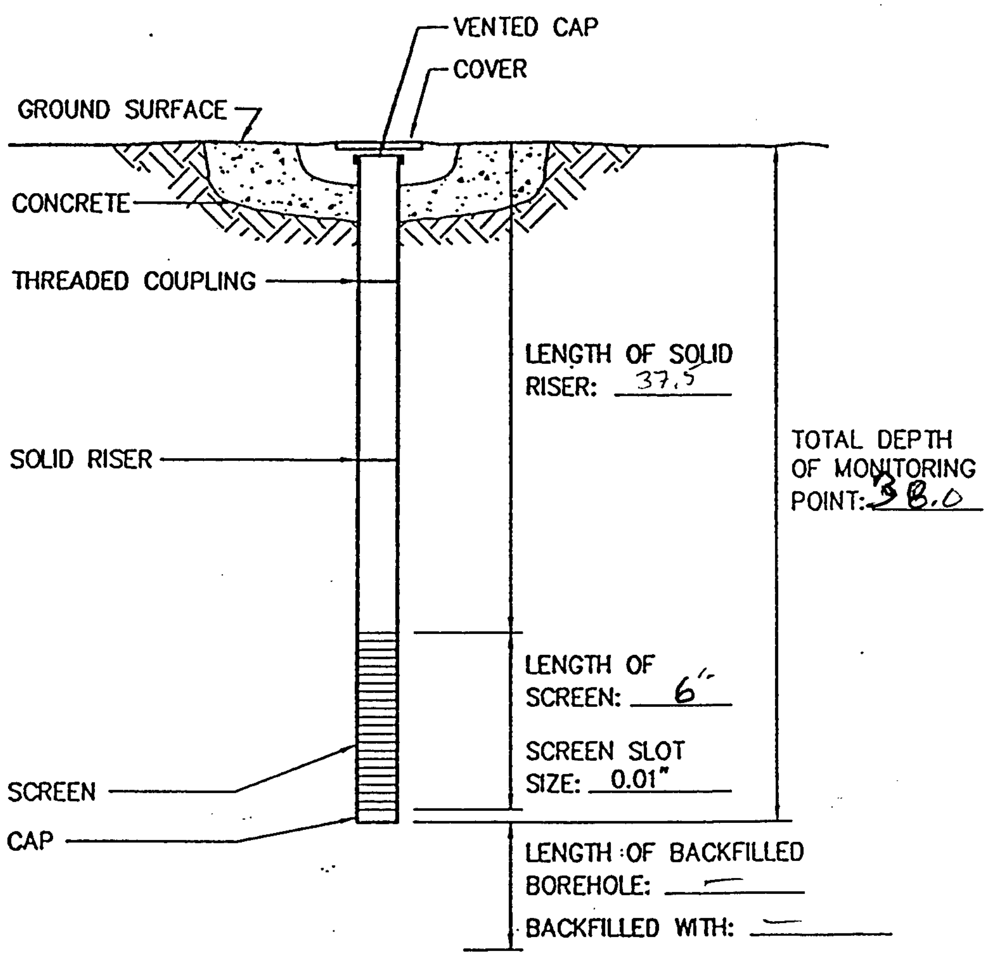
MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-12
JOB NUMBER 722450.28 INSTALLATION DATE Sept 14, 1996 LOCATION Zone 1
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______
DATUM FOR WATER LEVEL MEASUREMENT NA
SCREEN DIAMETER & MATERIAL 0.375" - Stainless SLOT SIZE 0.010
RISER DIAMETER & MATERIAL 0.375" - HDPE BOREHOLE DIAMETER 1.0"
CONE PENETROMETER CONTRACTOR Parsons ES ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 38 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-13

JOB NUMBER 722450.28 INSTALLATION DATE Sept 14, 1996 LOCATION Zone 1

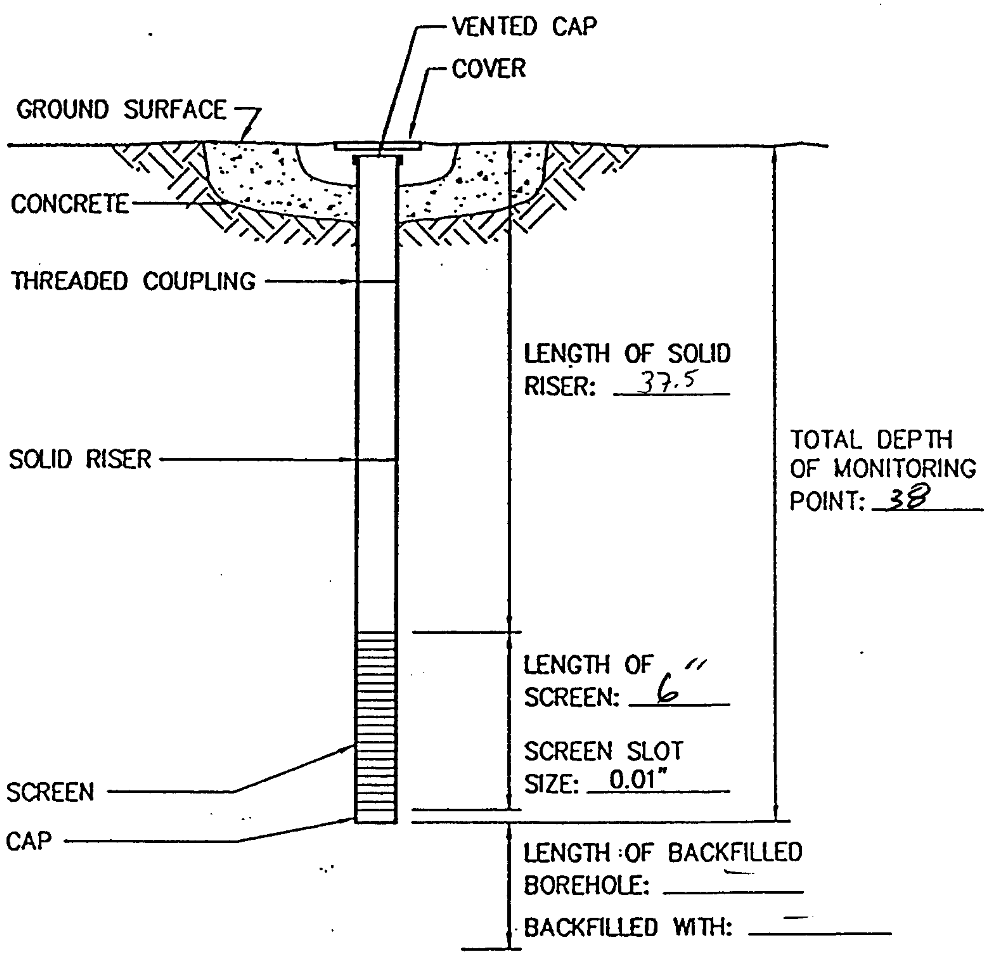
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT NA

SCREEN DIAMETER & MATERIAL 0.375" - Stainless SLOT SIZE 0.010

RISER DIAMETER & MATERIAL 0.375" - PVC BOREHOLE DIAMETER 1.0"

CONE PENETROMETER CONTRACTOR Parsons ES ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 38 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER 14(S)

JOB NUMBER 722450.28 INSTALLATION DATE SEPT 14, 1996 LOCATION ZONE 1

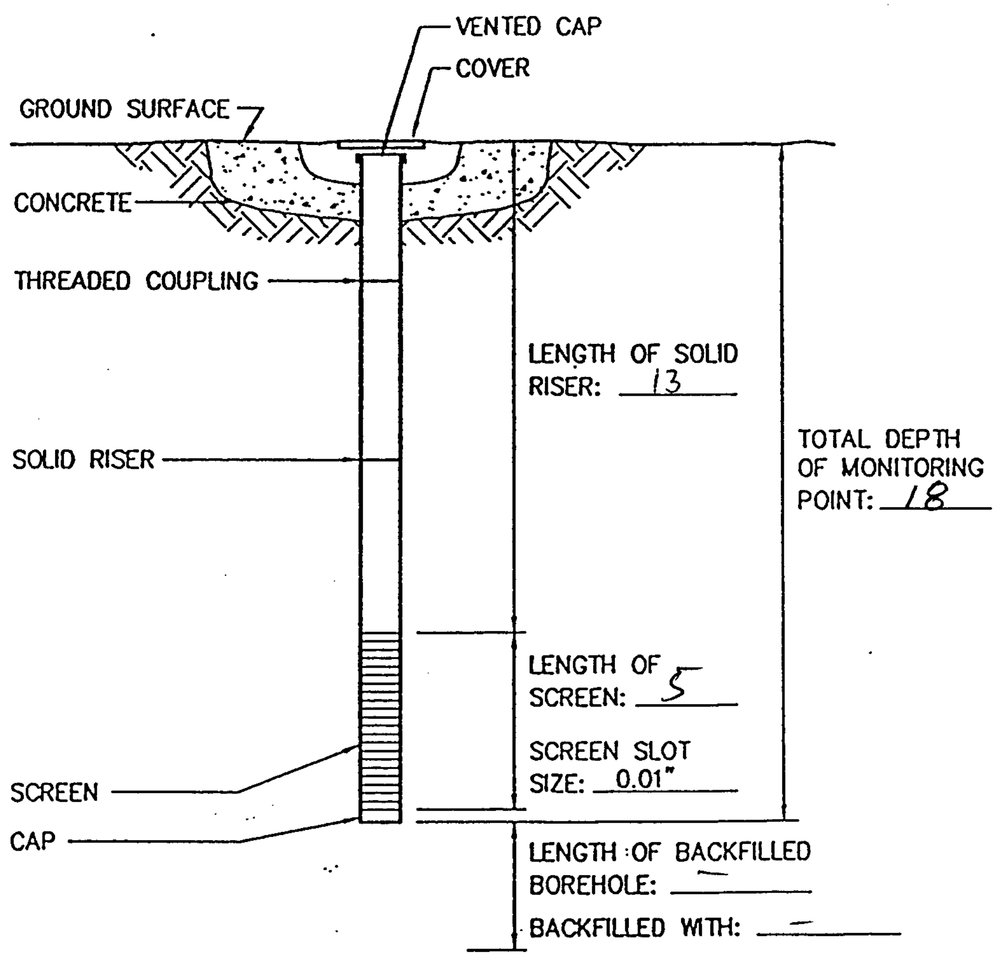
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT ~~AT~~ Top of Casing

SCREEN DIAMETER & MATERIAL 0.5" - PVC SLOT SIZE 0.010

RISER DIAMETER & MATERIAL 0.5" - PVC BOREHOLE DIAMETER 2.0

CONE PENETROMETER CONTRACTOR Parsons ES ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 18 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

MONITORING POINT INSTALLATION RECORD

JOB NAME WESTOVER ARB MONITORING POINT NUMBER MP-14(D)

JOB NUMBER 722450.28 INSTALLATION DATE SEPT 14, 1996 LOCATION ZONE 1

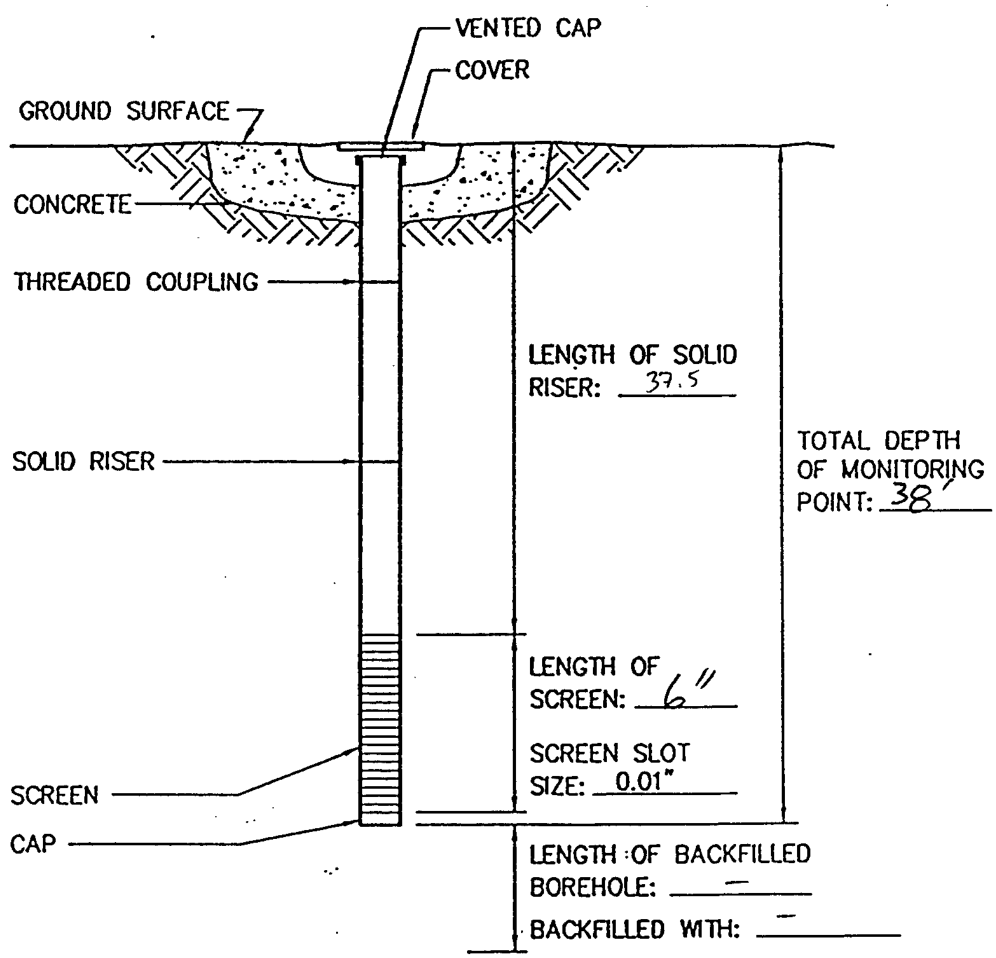
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______

DATUM FOR WATER LEVEL MEASUREMENT NA

SCREEN DIAMETER & MATERIAL 0.375" Stainless SLOT SIZE 0.010

RISER DIAMETER & MATERIAL 0.375" - HDPE BOREHOLE DIAMETER 1.0"

CONE PENETROMETER CONTRACTOR Parsons ES ES REPRESENTATIVE MJV



(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH 38 FEET BELOW DATUM.

GROUND SURFACE ______ FEET

MONITORING POINT INSTALLATION RECORD

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.

Denver, Colorado

AQUIFER SLUG TEST DATA SHEET

Location: WESTOVER ARB-ZONE 1
Job No.: 722450.28
Water Level ____
Depth ____
Measuring Datum ____
Weather ____
Comments ____

Client: AFCEE
Field Scientist ____
Total Well
Elevation of Datum ____
Temp ____

Well No. MW-16
Date 9/16/96

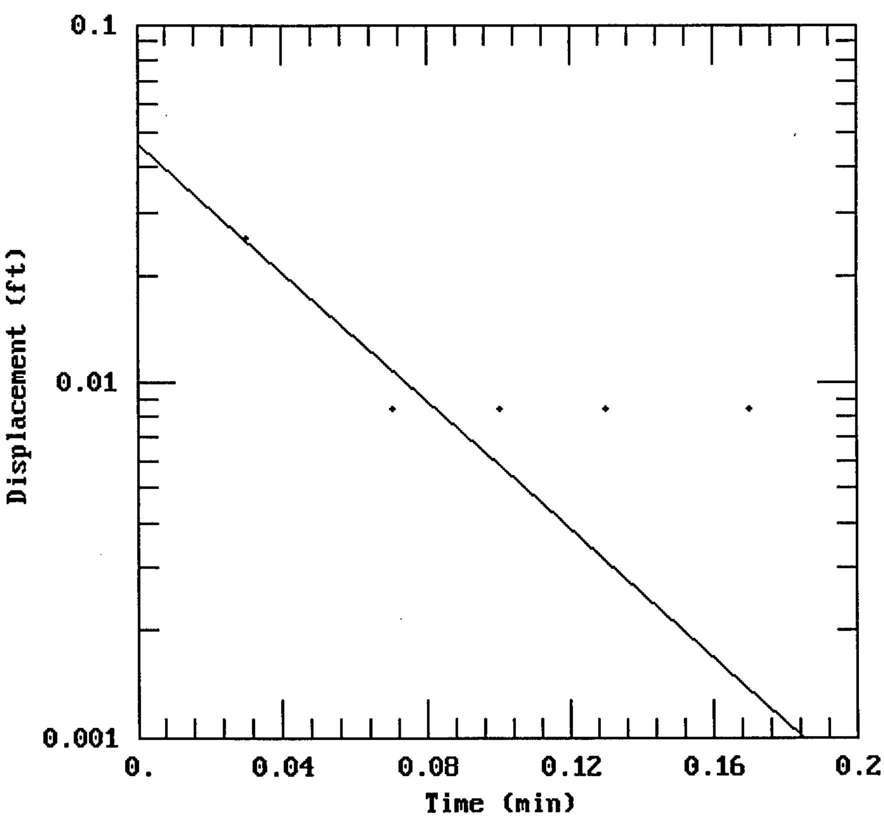
Beginning Time	Ending Time	Initial Head Reading	Ending Head Reading	Test Type (Rise/Fall)	File Name	Comments
11:14	11:17	7.5199	7.5199	FALL	WMW16F1	
11:18	11:18	7.5199	7.5199	RISE	WMW16R1	
11:19	11:21	7.5199	7.5283	FALL	WMW16F2	
11:22	11:23	7.5283	7.5283	RISE	WMW16R2	

AQUIFER TEST
DATA FORM

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS
ENGINEERING SCIENCE, INC.
Denver, Colorado

MW16f1



DATA SET:
WMW16F1.DAT
01/30/97

AQUIFER MODEL:
Unconfined

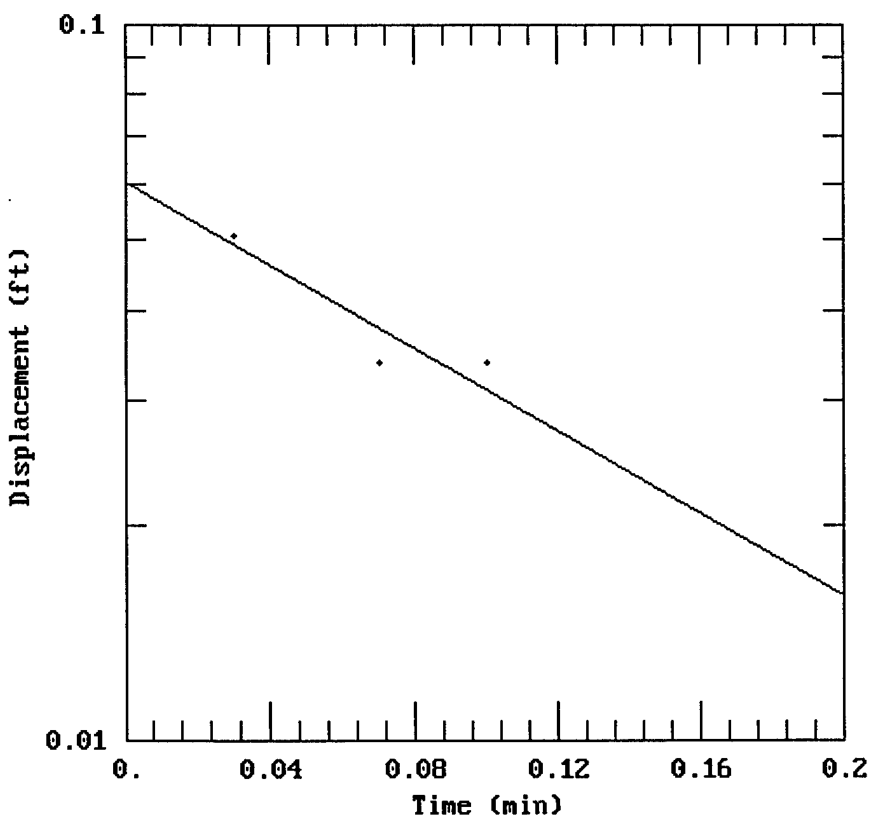
SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 1. ft
r_c= 0.08 ft
r_w= 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

PARAMETER ESTIMATES:
K = 0.04407 ft/min
y0 = 0.04633 ft

AQTESOLV

MW16f2



DATA SET:
WMW16F2.DAT
01/30/97

AQUIFER MODEL:
Unconfined

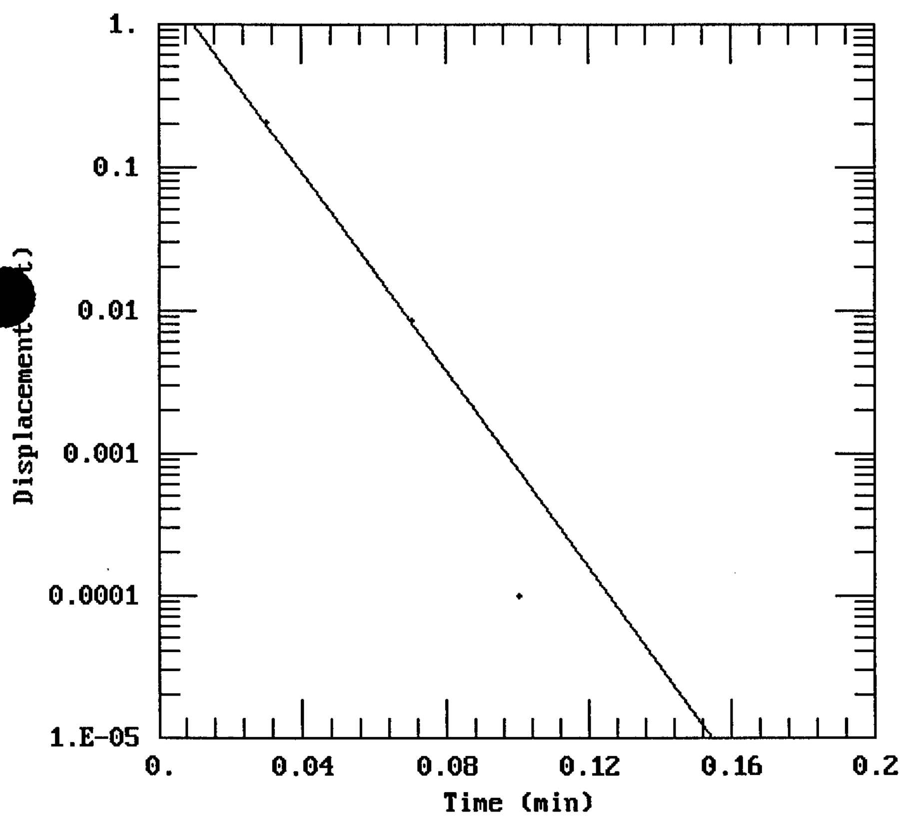
SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 1. ft
r_c= 0.08 ft
r_w= 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

PARAMETER ESTIMATES:
K = 0.01413 ft/min
y0 = 0.06029 ft

AQTESOLV

MW16r1



DATA SET:
WMW16R1.DAT
01/30/97

AQUIFER MODEL:
Unconfined

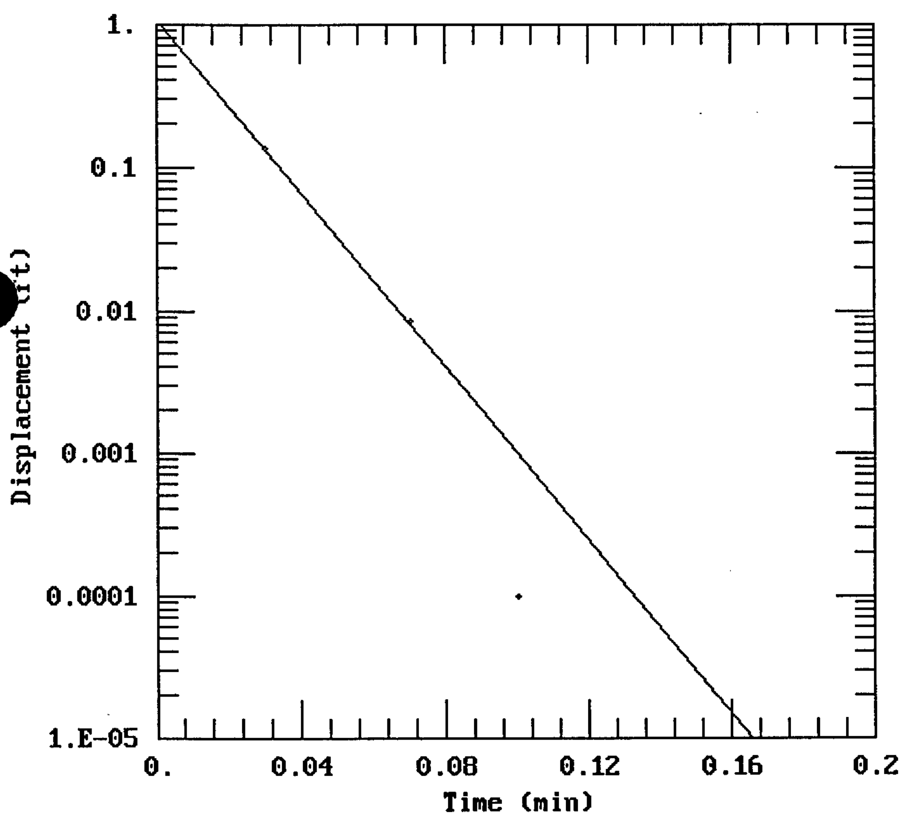
SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 1. ft
r_c= 0.08 ft
r_w= 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

PARAMETER ESTIMATES:
K = 0.169 ft/min
y0 = 2.21 ft

AQTESOLV

MW16r2



DATA SET:
WMW16R2.DAT
01/30/97

AQUIFER MODEL:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATA:
H0= 1. ft
r_c= 0.08 ft
r_w= 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

PARAMETER ESTIMATES:
K = 0.1487 ft/min
y0 = 1.105 ft

AQTESOLV

AQUIFER SLUG TEST DATA SHEET

Location: Westover ARB-Zone 1 Client: AFCEE Well No. ECS-27
Job No.: 722450.28 Field Scientist____ Date 9/16/96
Water Level____ Total Well
Depth____
Measuring Datum____ Elevation of Datum____
Weather____ Temp____
Comments____

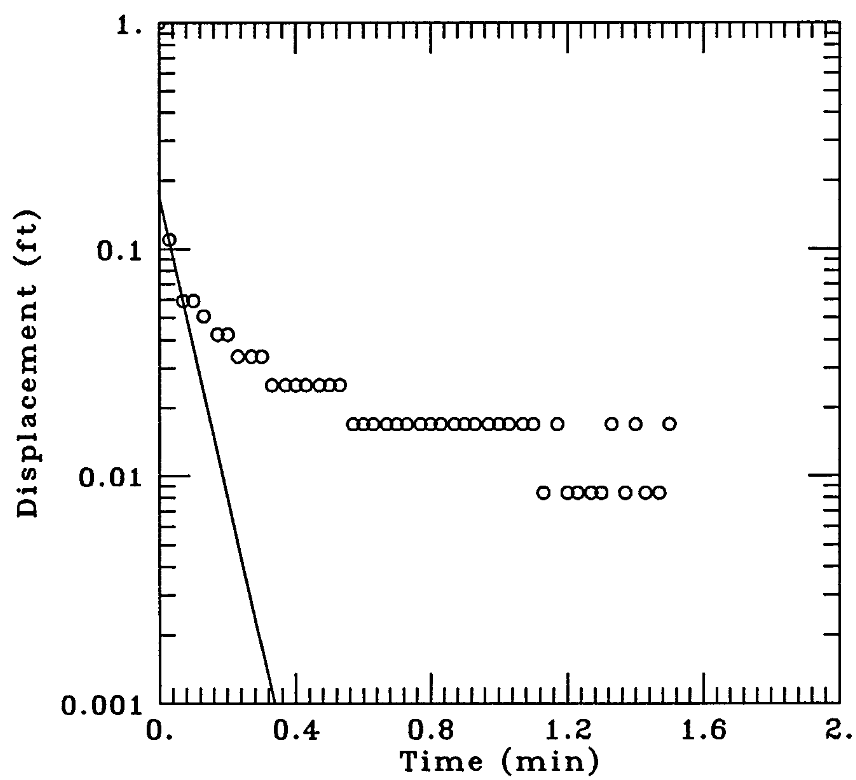
Beginning Time	Ending Time	Initial Head Reading	Ending Head Reading	Test Type (Rise/Fall)	File Name	Comments
9:56	9:59	2.7460	2.8051	FALL	WECS27F1	
10:00	10:02	2.7882	2.7291	Rise	WECS27R1	
10:02	10:06	2.7460	2.7967	Fall	WECS27F2	
10:06	10:12	2.7882	2.7544	~~Rise~~ Fall	WECS27R2	Fall test (not Rise)

AQUIFER TEST DATA FORM

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

westover-well ecs-30 falling head test 1



DATA SET:

10/04/96

AQUIFER TYPE:

Unconfined

SOLUTION METHOD:

Bouwer-Rice

ESTIMATED PARAMETERS:

K = 0.00468 ft/min

y0 = 0.1674 ft

TEST DATA:

H0 = 1. ft

rc = 0.083 ft

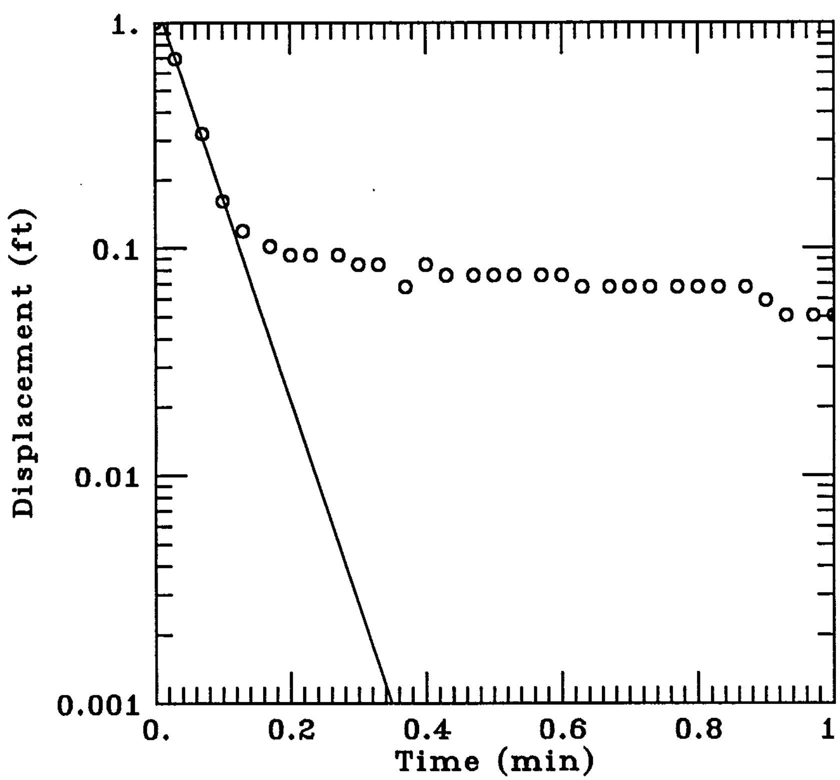
rw = 0.33 ft

L = 10. ft

b = 10. ft

H = 1. ft

westover-well ecs-27 rising head test 1



DATA SET:

10/04/96

AQUIFER TYPE:

Unconfined

SOLUTION METHOD:

Bouwer-Rice

ESTIMATED PARAMETERS:

K = 0.006335 ft/min
y0 = 1.3 ft

TEST DATA:

H0 = 1. ft
rc = 0.083 ft
rw = 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

AQUIFER SLUG TEST DATA SHEET

Location: Westover ARB-Zone 1
Job No.: 722450.28
Water Level
Depth
Measuring Datum
Weather
Comments

Client: AFCEE
Field Scientist
Total Well
Elevation of Datum
Temp

Well No. ECS 30
Date 9/16/96

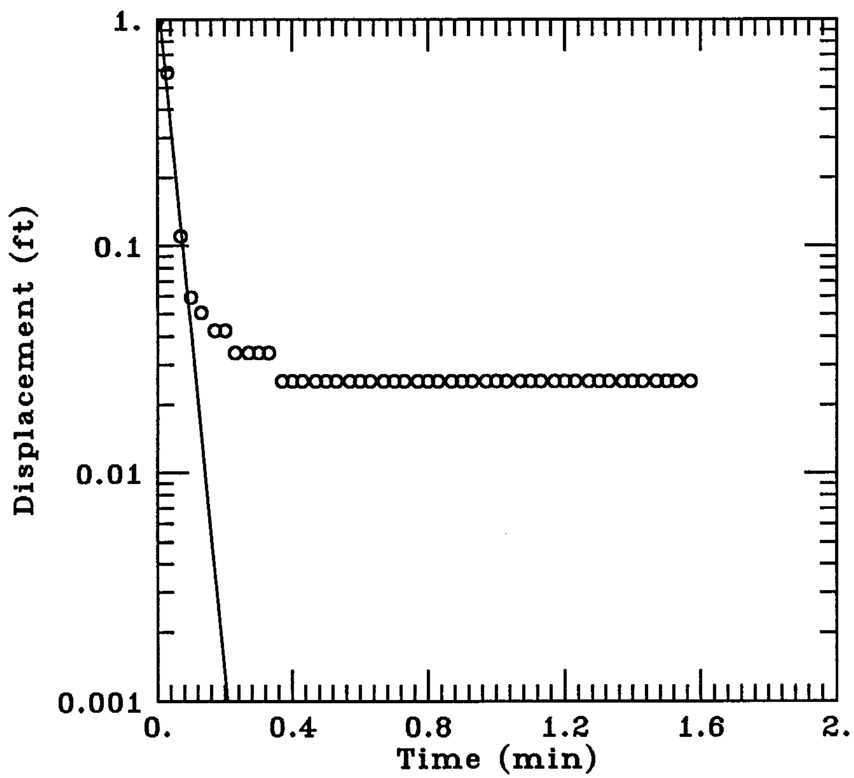
Beginning Time	Ending Time	Initial Head Reading	Ending Head Reading	Test Type (Rise/Fall)	File Name	Comments
8:23	8:25	2.4587	2.4672	FALL	WECS30F1	no head data
8:26	8:27	2.4672	2.4672	Rise	WECS30R1	
8:28	8:30	2.4672	2.4756	FALL	WECS30F2	
8:30	8:31	2.4756	2.4672	Rise	WECS30R2	

AQUIFER TEST
DATA FORM

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

westover-well ecs-31 falling head test 1



DATA SET:

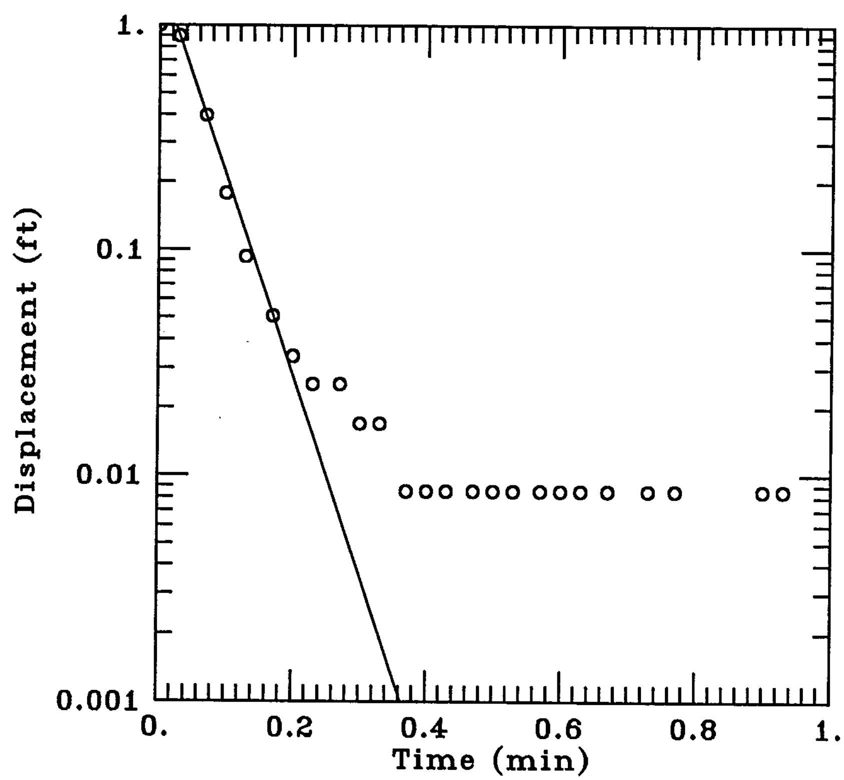
10/04/96

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice

ESTIMATED PARAMETERS:
K = 0.01069 ft/min
y0 = 1.334 ft

TEST DATA:
H0 = 1. ft
rc = 0.083 ft
rw = 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

westover-well ecs-30 rising head test 1



DATA SET:

10/04/96

AQUIFER TYPE:

Unconfined

SOLUTION METHOD:

Bouwer-Rice

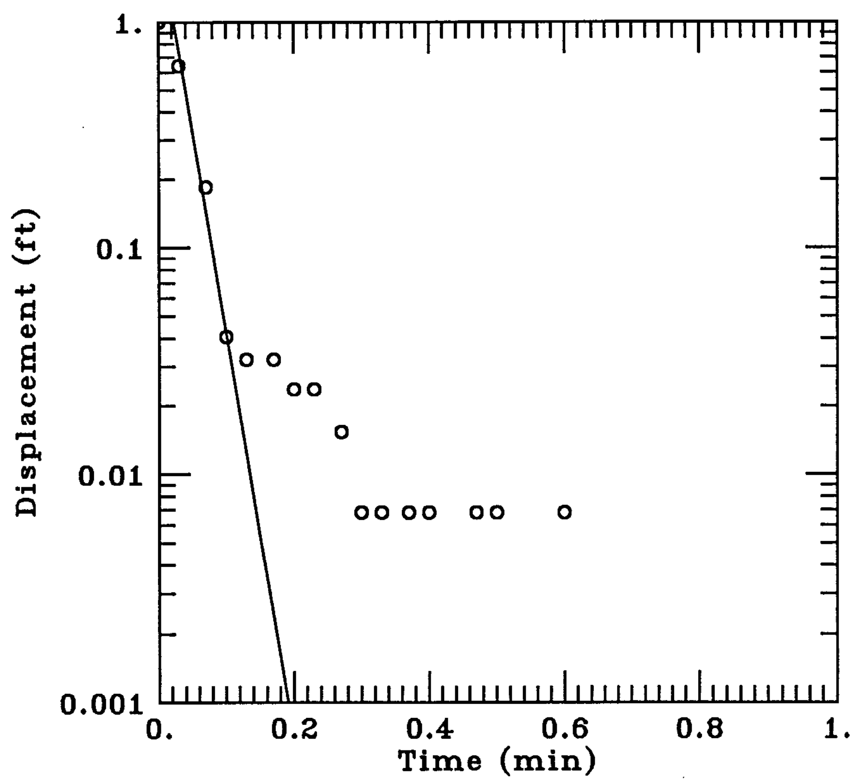
ESTIMATED PARAMETERS:

K = 0.006293 ft/min
y0 = 1.654 ft

TEST DATA:

H0 = 1. ft
rc = 0.083 ft
rw = 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

westover-well ecs-31 falling head test 2



DATA SET:

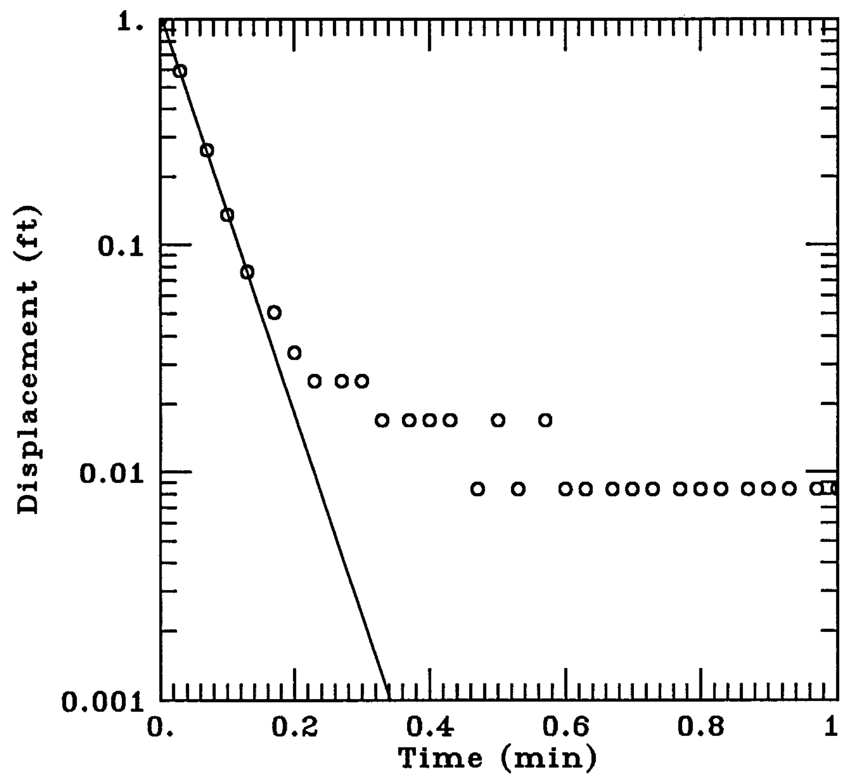
10/04/96

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice

ESTIMATED PARAMETERS:
K = 0.01261 ft/min
y0 = 2.522 ft

TEST DATA:
H0 = 1. ft
rc = 0.083 ft
rw = 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

westover-well ecs-30 rising head test 2



DATA SET:

10/04/96

AQUIFER TYPE:

Unconfined

SOLUTION METHOD:

Bouwer-Rice

ESTIMATED PARAMETERS:

K = 0.006291 ft/min
y0 = 1.078 ft

TEST DATA:

H0 = 1. ft
rc = 0.083 ft
rw = 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

AQUIFER SLUG TEST DATA SHEET

Location: Westover ARB-Zone 1 | Client: AFCEE | Well No. ECS-31

Job No.: 722450.28 | Field Scientist_____ | Date 9/16/96

Water Level_____ | Total Well

Depth_____

Measuring Datum_____ | Elevation of Datum_____

Weather_____ | Temp_____

Comments_____

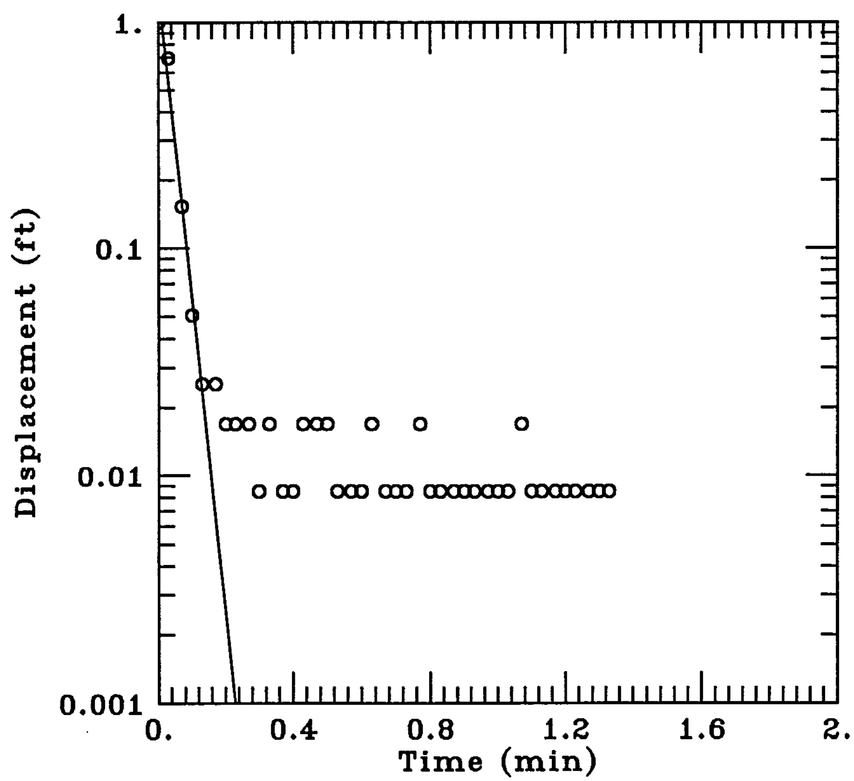
Beginning Time	Ending Time	Initial Head Reading	Ending Head Reading	Test Type (Rise/Fall)	File Name WECS31F1	Comments
7:53	7:56	6.0412	6.0666	~~Rise~~ Fall	~~WECS~~	
7:56	7:59	6.0~~666~~412	6.0581	Rise	WECS31R1	
7:59	8:01	6.0581	6.0835	Fall	WECS31F2	
8:02	8:04	6.0750	6.0750	Rise	WECS31R2	

AQUIFER TEST DATA FORM

Zone 1
Remediation By Natural Attenuation TS
Westover ARB, Massachusetts

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

westover-well ecs-31 rising head test 1



DATA SET:

10/04/96

AQUIFER TYPE:

Unconfined

SOLUTION METHOD:

Bouwer-Rice

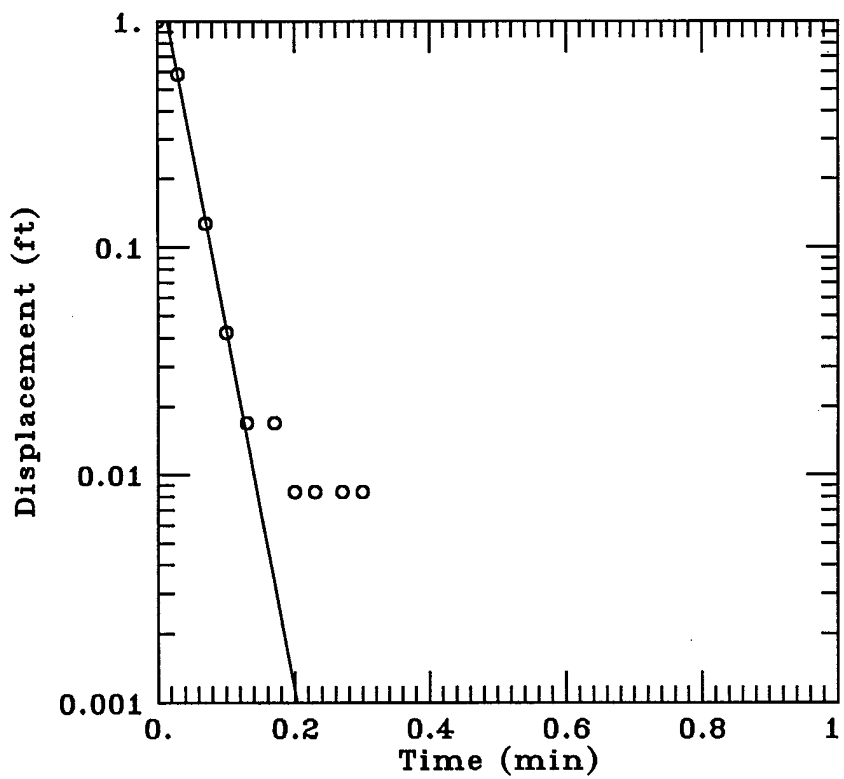
ESTIMATED PARAMETERS:

K = 0.009701 ft/min
y0 = 1.4 ft

TEST DATA:

H0 = 1. ft
rc = 0.083 ft
rw = 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

westover-well ecs-31 rising head test 2



DATA SET:

10/04/96

AQUIFER TYPE:

Unconfined

SOLUTION METHOD:

Bouwer-Rice

ESTIMATED PARAMETERS:

K = 0.01132 ft/min
y0 = 1.729 ft

TEST DATA:

H0 = 1. ft
rc = 0.083 ft
rw = 0.33 ft
L = 10. ft
b = 10. ft
H = 1. ft

APPENDIX B

SOIL AND GROUNDWATER ANALYTICAL RESULTS

SEPTEMBER 1996

Evergreen Analytical Laboratory

CASE NARRATIVE

Evergreen Analytical Laboratory (EAL) Projects: 96-3151, 96-3185 96-3213, 96-3235, 96-3237 and 96-3252

Parsons Engineering Science, Inc. (PES) Project: Westover ARB 729691.28010

Sample Receipt

Between September 11 and 17, 1996, soil and groundwater samples were received at EAL for analysis under Subcontract 722450.SC02. Refer to the EAL Check-in portion of the Chain of Custody for specific information regarding the condition of samples upon receipt. Refer to the EAL Work Order Summary for log-in information and cross-reference of EAL and PES sample identifications.

Data Package

All data are reported in one comprehensive package that is segregated based upon EAL project number. Each EAL project represents a group of samples received on a given day. The EAL Work Order Summary lists the samples represented in each EAL project.

A separate invoice for each EAL project number will be generated.

Quality assurance data may overlap from one EAL project to another. All required matrix spike/matrix spike duplicate (MS/MSD) and laboratory control samples (LCS) were analyzed when required and also are included in the data package.

BTEX, Method SW8020/Total Volatile Hydrocarbons TVH, Method SW8015M

All samples were analyzed for BTEX/TVH within holding time.

Several samples were analyzed at dilutions ranging from a dilution factor of 5 to 100 due to elevated levels of contaminants. The reporting limits have been raised accordingly.

The 1,2,4 TCB surrogate recovery for BTEX was below the acceptance criteria in samples MP-2 and SS-4. These soil samples were reprepared and reanalyzed within holding time with similar results. The original data are reported.

There are no other quality control anomalies to report.

Methane, Method RSKSOP-175M

All samples submitted for Methane analysis were analyzed within holding time.

Several samples were analyzed at dilutions ranging from a dilution factor of 10 and 50 due to elevated levels of Methane. The reporting limits have been raised accordingly.

There are no quality control anomalies to report.

Purgeable Halogenated Volatile Organics, Method SW8010B

All samples submitted for SW8010 analysis were analyzed within holding time.

Sample IW-3 was analyzed normally and at a dilution of 5 in order to quantitate the concentration of cis-1,2-Dichloroethene present. The reporting limit for c-1,2-DCE was adjusted accordingly.

1,1-Dichloroethene was detected at 0.37 ppb in the reagent blank. As the EAL reporting limit is 0.4, the blank value for this compound is considered non-detect. Two samples exhibited detects for 1,1-DCE at levels just above the EAL reporting limit, but less than the PES contract required limit of 1.0 ppb. The samples are J and X flagged.

There are no other quality control anomalies to report.

Anions, Method EPA 300.0

The holding time for nitrate analysis on sample MP-10 expired prior to analysis due to laboratory error. This sample was analyzed as nitrate/nitrite-N within holding time. The sample is R flagged for the nitrate analysis, and the combined nitrate/nitrite-n result is reported on the spreadsheet under nitrite.

All samples for nitrate analysis taken on Sept. 14 were received at EAL past holding time. Again, the results are reported as nitrate + nitrite-N. Please note the reporting limit has been raised from 0.056 to 0.076 mg/L.

General Chemistry

There are no quality control anomalies to report for the following analyses: Alkalinity by Method E310.1 or Total Organic Carbon in water by Method E415.1.

Total Organic Carbon in Soil

Total organic carbon (TOC) in soil was analyzed by Huffman Laboratories of Golden Colorado. TOC was determined by analyzing for total carbon (TC) and inorganic (carbonate) carbon (CC), then calculating the difference as TOC. The reports from Huffman are included.

Disk Deliverables

The disk deliverables are included with the hard copy data package. MS/MSD and LCS results are not included on the disk. Please note that blank spaces in the laboratory detection limit and/or practical quantitation limit (PQL) column indicate that there is no detection limit or PQL for that analyte.

Reporting limits have been adjusted to reflect percent moisture in all soil samples or increases due to dilutions.

A hard copy of each spreadsheet from the diskette is included. The name for each spreadsheet is located in the top left corner on the first page of each printout.

Patricia A. McClellan

Patricia A. McClellan, Program Manager
10/14/96

Evergreen Analytical, Inc.

96-3151

WORK ORDER Summary

16-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3151-05A	MP-1	% Moisture for dry weight calculation Revision 9/16/96		Soil	2	10-Sep-96	11-Sep-96	25-Sep-96	08-Oct-96
96-3151-01G	MW-38	Anions by IC Cl,SO4,NO2,NO3		Groundwater	A4			25-Sep-96	12-Sep-96
96-3151-02G	OBG-41	Anions by IC Cl,SO4,NO2,NO3						25-Sep-96	12-Sep-96
96-3151-03G	ECS-31	Anions by IC Cl,SO4,NO2,NO3						25-Sep-96	12-Sep-96
96-3151-04G	MW-36	Anions by IC Cl,SO4,NO2,NO3						25-Sep-96	12-Sep-96
96-3151-05A	MP-1	BTEX		Soil	2			18-Sep-96	24-Sep-96
96-3151-01A	MW-38	BTEX + TVPH (Parsons List)		Groundwater				18-Sep-96	24-Sep-96
96-3151-02A	OBG-41	BTEX + TVPH (Parsons List)						18-Sep-96	24-Sep-96
96-3151-03A	ECS-31	BTEX + TVPH (Parsons List)						18-Sep-96	24-Sep-96
96-3151-04A	MW-36	BTEX + TVPH (Parsons List)						18-Sep-96	24-Sep-96
96-3151-06A	Trip Blank	BTEX / TVPH Combo		Water		11-Sep-96		18-Sep-96	25-Sep-96
96-3151-01D	MW-38	Methane		Groundwater		10-Sep-96		25-Sep-96	24-Sep-96
96-3151-02D	OBG-41	Methane						25-Sep-96	24-Sep-96
96-3151-03D	ECS-31	Methane						25-Sep-96	24-Sep-96
96-3151-04D	MW-36	Methane						25-Sep-96	24-Sep-96
96-3151-01H	MW-38	Total Alkalinity			A4			25-Sep-96	24-Sep-96
96-3151-03H	ECS-31	Total Alkalinity						25-Sep-96	24-Sep-96
96-3151-01I	MW-38	Total Organic Carbon						25-Sep-96	08-Oct-96
96-3151-03I	ECS-31	Total Organic Carbon						25-Sep-96	08-Oct-96

\# = Special list. See sample comments or test information.
HT = Holding Time expiration date.

Evergreen Analytical, Inc.

96-3151

WORK ORDER Summary

16-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3151-05B	MP-1	Total Organic Carbon Revision 9/16/96		Soil	Out	10-Sep-96	11-Sep-96	25-Sep-96	17-Sep-96

# = Spe[illegible]list. See sample comments or test information.
HT = H[illegible]g Time expiration date.

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CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

Page 1 of ____

Evergreen Analytical Inc.
4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

COMPANY: Parsons E.S.
ADDRESS: 1700 Broadway Suite 900
CITY: Denver STATE: CO ZIP: 80290
PHONE#: 303-831-8100 FAX #: 831-8208 FAX RESULTS Y / N

CLIENT CONTACT (print): Dave Moutoux
CLIENT PROJ. I.D.: 729691.28010
EAL QUOTE #: ____ P.O.#: ____
TURNAROUND REQUIRED*: ☒ STD (2 wks) ☐ UST ☐ Other (Specify)*
*expedited turnaround subject to additional fee

Sampler Name:
(signature) Saskia Hoffer
(print) Saskia Hoffer

Please **PRINT** all information:

EAL use only — Do not write in shaded area
W.O. # 96-3151
B.O.F. # NA
C/S (O) NA / NA
C/S (I) NA / CO
Cooler Temp. °C 7
Seals Intact Y / N / NA
Samples Pres. Y / N / NA
Headspace Y / N / NA

CLIENT SAMPLE IDENTIFICATION	DATE SAMPLED	TIME	No. of Containers	Water-Drinking/Discharge/Ground (circle)	Soil / Solid / Air / Gas	Oil / Sludge / Multi-phase	TCLP VOA/BNA/Pest/Herb/Metals (circle)	VOA 8260/624/524.2 (circle)	BNA 8270/625 (circle)	Pesticides 8080/608 (circle)	Pest/PCBs 8080/608/508 (circle)	PCB Screen	Herbicides 8150/515 (circle)	BTEX 8020/602 (circle)/MTBE (circle)	TVPH 8015mod. (Gasoline)	TEPH 8015mod. (Diesel)	Total Metals-DW / NPDES / SW846 (circle & list metals below)	Dissolved Metals - DW / SW846 (circle & list metals below)	Oil & Grease 413.1	TRPH 418.1	Alkalinity	TOC	Anions Cl⁻, SO4, NO2, NO3	methane			EAL use only
MW-38	9/10/96	10:15	9	X										3	3						X	X	X	X			01 A-I
OBG-40 pm	9/10/96	11:45	7	X										X	X								X	X			02 A-G
ECS-31	9/10/96	13:30	9	X										X	X						X	X	X	X			03 A-I
MW-36	9/10/96	15:30	7	X										X	X								X	X			04 A-G
IMP-1	9/10/96	15:30	2		X									X								X		~~X~~			05 A-B
Trip Blank	~~HOLD~~	pm	1								pm ~~HOLD~~			~~X~~	X												06 A
															Meth.												
														AC	~~DF~~						H	III	G	D-F			
Sample Fraction																											Loc A4,2
Instructions:														40V	40V						250 P	125 A	125 P				Cont

All samples packed on ice! All samples for OBG-40 labeled as OBG-41. 3 bottles received for methane on all waters. Not marked on COC. Run methane + trip blank for BTEX/TVH per Saskia Hoffer 9/12/96 pm

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Saskia Hoffer	9/10 17:00	FEDEX	9/10	Fedex		[signature]	09/11/96 10:25

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number : MB1091296
Date Prepared : 9/12/96
Dilution Factor : 1.0

Client Project Number : 729691.28010
Lab Work Order : 96-3151
Matrix : WATER
Lab File Number : TVB10912009

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/12/96	U	0.1	mg/L
Benzene	71-43-2	9/12/96	U	0.4	ug/L
Toluene	108-88-3	9/12/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/12/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/12/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/12/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/12/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/12/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/12/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/12/96	U	0.5	ug/L
FID Surrogate Recovery:		99%		70%-121%	(Limits)
PID Surrogate Recovery:		102%		82%-115%	(Lim

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB1091396	Client Project Number	: 729691.28010
Date Prepared	: 9/13/96	Lab Work Order	: 96-3151
Dilution Factor	: 1.0	Matrix	: WATER
		Lab File Number	: TVB10912035

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/13/96	U	0.1	mg/L
Benzene	71-43-2	9/13/96	U	0.4	ug/L
Toluene	108-88-3	9/13/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/13/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/13/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/13/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/13/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/13/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/13/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/13/96	U	0.5	ug/L
FID Surrogate Recovery:		100%		70%-121%	(Limits)
PID Surrogate Recovery:		103%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:
E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-38	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3151-01	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	Matrix	: WATER
Date Received	: 9/11/96	Lab File Number(s)	: TVB10912037
Date Prepared	: 9/13/96	Method Blank	: MB1091396
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/13/96	U	0.1	mg/L
Benzene	71-43-2	9/13/96	U	0.4	ug/L
Toluene	108-88-3	9/13/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/13/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/13/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/13/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/13/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/13/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/13/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/13/96	U	0.5	ug/L
FID Surrogate Recovery:		98%		70%-121%	(Lim
PID Surrogate Recovery:		102%		82%-115%	(Lim

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Analyst

K. Hollman
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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: OBG-41	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3151-02	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	Matrix	: WATER
Date Received	: 9/11/96	Lab File Number(s)	: TVB10912038
Date Prepared	: 9/13/96	Method Blank	: MB1091396
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/13/96	U	0.1	mg/L
Benzene	71-43-2	9/13/96	U	0.4	ug/L
Toluene	108-88-3	9/13/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/13/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/13/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/13/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/13/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/13/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/13/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/13/96	U	0.5	ug/L
FID Surrogate Recovery:		100%		70%-121%	(Limits)
PID Surrogate Recovery:		105%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: ECS-31	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3151-03	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	Matrix	: WATER
Date Received	: 9/11/96	Lab File Number(s)	: TVB10912039,51
Date Prepared	: 9/13/96	Method Blank	: MB1091396
FID Dilution Factor	: 25		
PID Dilution Factor	: 25,50		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/13/96	5.7	2.5	mg/L
Benzene	71-43-2	9/13/96	U	10	ug/L
Toluene	108-88-3	9/13/96	150	10	ug/L
Chlorobenzene	108-90-7	9/13/96	U	10	ug/L
Ethyl Benzene	100-41-4	9/13/96	660	10	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/13/96	2900	20	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/13/96	170	10	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/13/96	410	10	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/13/96	240	10	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/13/96	25	12.5	ug/L
FID Surrogate Recovery:		98%		70%-121%	(Lim[illegible]
PID Surrogate Recovery:		99%,96%		82%-115%	(Lim[illegible]

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-36	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3151-04	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	Matrix	: WATER
Date Received	: 9/11/96	Lab File Number(s)	: TVB10912011
Date Prepared	: 9/12/96	Method Blank	: MB1091296
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/12/96	U	0.1	mg/L
Benzene	71-43-2	9/12/96	U	0.4	ug/L
Toluene	108-88-3	9/12/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/12/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/12/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/12/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/12/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/12/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/12/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/12/96	U	0.5	ug/L
FID Surrogate Recovery:		99%		70%-121%	(Limits)
PID Surrogate Recovery:		101%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-1	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3151-05	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	Matrix	: SOIL
Date Received	: 9/11/96	Lab File Number(s)	: TVB10912010
Date Prepared	: 9/12/96	Method Blank	: MB1091296
FID Dilution Factor	: 1.0	Soil Extracted?	: NO
PID Dilution Factor	: 1.0	Soil Moisture	: 17.57%

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	NA	NA	NA	NA
Benzene	71-43-2	9/12/96	U	0.5	ug/kg
Toluene	108-88-3	9/12/96	U	0.5	ug/kg
Chlorobenzene	108-90-7	9/12/96	U	0.5	ug/kg
Ethyl Benzene	100-41-4	9/12/96	U	0.5	ug/kg
Total Xylenes (m,p,o)	1330-20-7	9/12/96	U	0.5	ug/kg
1,3,5-Trimethylbenzene	108-67-8	9/12/96	U	0.5	ug/kg
1,2,4-Trimethylbenzene	95-63-6	9/12/96	U	0.5	ug/kg
1,2,3-Trimethylbenzene	526-73-8	9/12/96	U	0.5	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	9/12/96	U	0.6	ug/kg
FID Surrogate Recovery:	NA			50%-132%	(Lim
PID Surrogate Recovery:		101%		72%-118%	(Limi

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: TRIP BLANK	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3151-06	Lab Work Order	: 96-3151
Date Sampled	: N/A	Matrix	: WATER
Date Received	: 9/11/96	Lab File Number(s)	: TVB10912036
Date Prepared	: 9/13/96	Method Blank	: MB1091396
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/13/96	U	0.1	mg/L
Benzene	71-43-2	9/13/96	U	0.4	ug/L
Toluene	108-88-3	9/13/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/13/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/13/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/13/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/13/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/13/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/13/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/13/96	U	0.5	ug/L
FID Surrogate Recovery:		99%		70%-121%	(Limits)
PID Surrogate Recovery:		102%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MW-38	Client Project No	: 729691.28010
Lab Sample No.	: 96-3151-01	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 9/11/96	Matrix	: WATER
Date Prepared	: 9/13/96	Lab File Number(s)	: TVB10912045,47
Date Analyzed	: 9/13/96	Method Blank	: MB1091396
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#) Limits %REC
Gasoline	2.00	0.00	2.02	100.8%	61 - 126
Surrogate **	---	---	---	98%	70 - 121

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#) Limits	
					RPD	%REC
Gasoline	2.00	1.82	90.8%	10.4	27	61 - 126
Surrogate **	---	---	94%	NA	NA	70 - 121

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:
NA = Not analyzed/not applicable.
* = Values outside of QC limits.
** = 1,2,4-Trichlorobenzene
# = Limits established 8/13/96, MAB

Comments: ______________________

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Evergreen Analytical, Inc.
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(303) 425-6021

EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MW-36	Client Project No.	: 729691.28010
Lab Sample No.	: 96-3151-04	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	EPA Method No.	: 602/8020
Date Received	: 9/11/96	Matrix	: WATER
Date Prepared	: 9/13,16/1996	Lab File Number(s)	: *
Date Analyzed	: 9/13,16/1996	Method Blanks	: **
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L)		Comments
			MS	MSD	
Benzene	20.0	0.0	18.8	18.9	
Toluene	20.0	0.0	19.0	18.9	
Chlorobenzene	20.0	0.0	19.5	19.2	
Ethylbenzene	20.0	0.0	19.5	19.2	
m,p-Xylene	20.0	0.0	19.4	19.1	
o-Xylene	20.0	0.0	19.7	19.3	
1,3,5-TMB	20.0	0.0	20.2	18.9	
1,2,4-TMB	20.0	0.0	19.9	18.3	
1,2,3-TMB	20.0	0.0	20.5	18.4	
1,2,3,4-TeMB	20.0	0.0	20.3	18.2	
Surrogate	100.0	101%	104%	91%	% RECOVERY

Compound		MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits	
					RPD	%REC
Benzene		94.0	94.5	0.5	20	59 - 130
Toluene		95.0	94.5	0.5	27	51 - 135
Chlorobenzene		97.5	96.0	1.6	8	60 - 126
Ethylbenzene		97.5	96.0	1.6	15	57 - 127
m,p-Xylene		97.0	95.5	1.6	21	50 - 137
o-Xylene		98.5	96.5	2.1	18	55 - 131
1,3,5-TMB		101.0	94.5	6.6	13	58 - 134
1,2,4-TMB		99.5	91.5	8.4	12	54 - 134
1,2,3-TMB		102.5	92.0	10.8	26	58 - 133
1,2,3,4-TeMB		101.5	91.0	10.9	23	49 - 141
Surrogate		104.0	91.0	NA	NA	82 - 115

#= Limits extablished 8/13/96, MAB.
*= Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments: * = TVB10912057 and TVB10916008; ** = MB1091396 and MB1091696

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Approved

Evergreen Analytical, Inc.
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(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MP-1	Client Project No	: 729691.28010
Lab Sample No.	: 96-3151-05	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 9/11/96	Matrix	: SOIL
Date Prepared	: 9/13/96	Lab File Number(s)	: TVB10912042,43
Date Analyzed	: 9/13/96	Method Blank	: MB1091396
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (mg/kg)	Sample Concentration (mg/kg)	MS Concentration (mg/kg)	MS %REC	QC (#) Limits %REC
Gasoline	2.00	0.00	1.93	96.3%	50 - 127
Surrogate **	---	---	---	96%	50 - 132

Compound	Spike Added (mg/kg)	MSD Concentration (mg/kg)	MSD %REC	RPD	QC (#) Limits RPD	QC (#) Limits %REC
Gasoline	2.00	2.02	101.2%	5.0	50	50 - 127
Surrogate **	---	---	96%	NA	NA	50 - 132

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:
NA = Not analyzed/not applicable.
* = Values outside of QC limits.
** = 1,2,4-Trichlorobenzene
# = Limits established 8/13/96, MAB

Comments:

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Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
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EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MP-1	Client Project No.	: 729691.28010
Lab Sample No.	: 96-3151-05	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	EPA Method No.	: 602/8020
Date Received	: 9/11/96	Matrix	: SOIL
Date Prepared	: 9/13/96	Lab File Number(s)	: TVB1 0912040,41
Date Analyzed	: 9/13/96	Method Blank	: MB1091396
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (ug/kg)	Sample Concentration (ug/kg)	Concentration (ug/kg) MS	MSD	Comments
Benzene	20.0	0.0	19.2	18.9	
Toluene	20.0	0.0	19.4	19.0	
Chlorobenzene	20.0	0.0	19.4	19.2	
Ethylbenzene	20.0	0.0	19.6	19.4	
m,p-Xylene	20.0	0.0	20.0	19.7	
o-Xylene	20.0	0.0	19.9	19.6	
1,3,5-TMB	20.0	0.0	19.6	19.9	
1,2,4-TMB	20.0	0.0	19.9	19.8	
1,2,3-TMB	20.0	0.0	20.0	19.8	
1,2,3,4-TeMB	20.0	0.0	19.3	19.9	
Surrogate	100.0	101%	102%	104%	% RECOVERY

Compound		MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits RPD	%REC	
Benzene		96.0	94.5	1.6	24	47 -	129
Toluene		97.0	95.0	2.1	26	46 -	134
Chlorobenzene		97.0	96.0	1.0	29	57 -	113
Ethylbenzene		98.0	97.0	1.0	30	32 -	136
m,p-Xylene		100.0	98.5	1.5	31	33 -	136
o-Xylene		99.5	98.0	1.5	22	32 -	134
1,3,5-TMB		98.0	99.5	1.5	27	44 -	121
1,2,4-TMB		99.5	99.0	0.5	25	40 -	123
1,2,3-TMB		100.0	99.0	1.0	26	42 -	120
1,2,3,4-TeMB		96.5	99.5	3.1	26	32 -	126
Surrogate		102.0	104.0	NA	NA	72 -	118

= Limits extablished 8/13/96, MAB.
* = Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments:

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Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form
Method Blank Report

Method Blank Number	: GB091396	Client Project No.	: 729691.28010
Date Extracted/Prepared	: 9/13/96	Lab Work Order	: 96-3151
Date Analyzed	: 9/13/96	Dilution Factor	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS0913002

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Holman
Approved

AF3151.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form

Client Sample Number	: MW-38	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3151-01	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	Dilution Factor	: 1.00
Date Received	: 9/11/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913006

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.003	0.002

Temperature	: 72.4 F	Saturation Concentration	Meth	0.000664989
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.002093659
Head space created	: 4 ml			
Methane Area	: 15.464 ug			
Atomic weight(Methane)	: 16 g			

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3151.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: OBG-41	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3151-02	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	Dilution Factor	: 1.00
Date Received	: 9/11/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913007

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	:	71.9 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	0 ug

Saturation Concentration Meth ______

Concentration in Head Space Meth ______

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3151.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: ECS-31	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3151-03	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	Dilution Factor	: 1.00
Date Received	: 9/11/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913008

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	:	72.1 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	0 ug
Atomic weight(Methane)	:	16 g

Saturation Concentration	Meth	0
Concentration in Head Space	Meth	0

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3151.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: ECS-31	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3151-03Dup	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	Dilution Factor	: 1.00
Date Received	: 9/11/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913009

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 72 F	Saturation	Meth	
Amount Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	
Head space created	: 4 ml	in Head Space		
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3151.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MW-36	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3151-04	Lab Work Order	: 96-3151
Date Sampled	: 9/10/96	Dilution Factor	: 1.00
Date Received	: 9/11/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913010

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 72.1 F	Saturation Concentration	Meth	0
Amount Injected	: 0.5 ml	Concentration in Head Space	Meth	0
Total Volume of Sample	: 43 ml			
Head space created	: 4 ml			
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

[signature] Analyst

K. Hollman Approved

AF3151.XLS

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane LCS Report Form

LCS No.	: LCS091396	EPA Method No.	: RSKSOP-175M
Date Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Method Blank	: GB091396
E.A. LCS Source No.	: 1886	Lab File No.	: GAS0913005

Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	413	83	67-85

Spike Recovery: 0 out of (1) outside limits.

Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available.

Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/10/96		Client Project ID.	:	729691.28010
Date Received	: 9/11/96		Lab Project Number	:	96-3151
Date Prepared	: 9/12/96		Method	:	EPA 300.0
Date Analyzed	: 9/12/96		Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride (mg/L)	Dilution Factor
96-3151-01	MW-38	Water	7.6	1
96-3151-01 Duplicate	MW-38 Duplicate	Water	7.4	1
96-3151-02	OBG-40	Water	40.6	1
96-3151-03	ECS-31	Water	3.7	1
96-3151-04	MW-36	Water	2.6	1
Method Blank	(9/12/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3151-01	MW-38 Matrix Spike	10.0	7.6	16.6	89
96-3151-01	MW-38 Matrix Spike Dup	10.0	7.6	16.3	87
MS/MSD RPD					2.9

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/10/96	Client Project ID.	: 729691.28010
Date Received	: 9/11/96	Lab Project Number	: 96-3151
Date Prepared	: 9/12/96	Method	: EPA 300.0
Date Analyzed	: 9/12/96	Detection Limit	: 0.076 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N (mg/L)	Dilution Factor
96-3151-01	MW-38	Water	<0.076	1
96-3151-01 Duplicate	MW-38 Duplicate	Water	<0.076	1
96-3151-02	OBG-40	Water	<0.076	1
96-3151-03	ECS-31	Water	<0.076	1
96-3151-04	MW-36	Water	<0.076	1
Method Blank	(9/12/96)		<0.076	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3151-01	MW-38 Matrix Spike	10.0	<0.25	9.4	94
96-3151-01	MW-38 Matrix Spike Dup	10.0	<0.25	9.5	95
MS/MSD RPD					0.1

* = Quality assurance results reported as Nitrite (NO_2).

Jeff Hal
Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/10/96	Client Project ID.	: 729691.28010
Date Received	: 9/11/96	Lab Project Number	: 96-3151
Date Prepared	: 9/12/96	Method	: EPA 300.0
Date Analyzed	: 9/12/96	Detection Limit	: 0.056 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrate-N (mg/L)	Dilution Factor
96-3151-01	MW-38	Water	3.5	1
96-3151-01 Duplicate	MW-38 Duplicate	Water	3.5	1
96-3151-02	OBG-40	Water	4.0	1
96-3151-03	ECS-31	Water	0.18	1
96-3151-04	MW-36	Water	2.2	1
Method Blank	(9/12/96)		<0.056	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3151-01	MW-38 Matrix Spike	10.0	15.3	25.4	100
96-3151-01	MW-38 Matrix Spike Dup	10.0	15.3	25.6	102
MS/MSD RPD					2.0

* = Quality assurance results reported as Nitrate (NO_3).

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/10/96		Client Project ID.	:	729691.28010
Date Received	: 9/11/96		Lab Project Number	:	96-3151
Date Prepared	: 9/12/96		Method	:	EPA 300.0
Date Analyzed	: 9/12/96		Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Sulfate (mg/L)	Dilution Factor
96-3151-01	MW-38	Water	12.3	1
96-3151-01 Duplicate	MW-38 Duplicate	Water	12.2	1
96-3151-02	OBG-40	Water	14.3	1
96-3151-03	ECS-31	Water	2.7	1
96-3151-04	MW-36	Water	5.7	1
Method Blank	(9/12/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3151-01	MW-38 Matrix Spike	10.0	12.3	22.1	99
96-3151-01	MW-38 Matrix Spike Dup	10.0	12.3	21.9	96
MS/MSD RPD					2.2

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Analysis Report

Date Sampled	: 9/10/96	Client Project ID.	: 729691.28010
Date Received	: 9/11/96	Lab Project Number	: 96-3151
Date Prepared	: 9/12/96	Method	: EPA 310.1
Date Analyzed	: 9/12/96	Detection Limit	: 5.0 mg $CaCO_3$/L

Evergreen Sample #	Client Sample ID.	Matrix	Total Alkalinity (mg $CaCO_3$/L)
96-3151-01	MW-38	Water	8.9
96-3151-03	ECS-31	Water	55.4
96-3151-03 Duplicate	ECS-31	Water	55.1
Method Blank			<5.0

Quality Assurance

Reference	True Value (mg$CaCO_3$/L)	Result (mg$CaCO_3$/L)	% Recovery
ERA Minerals Lot #9970	180	184	102

Analyst

Approved M A Bergmann

EVERGREEN ANALYTICAL, Inc.

4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Total Organic Carbon

Date Sampled	: 9/10/96		Client Project ID.	: 729691.28010
Date Received	: 9/11/96		Lab Project Number	: 96-3151
Date Prepared	: 9/19/96		Method	: EPA 415.1
Date Analyzed	: 9/19/96		Detection Limit	: 1.0 mg C/L

Evergreen Sample #	Client Sample ID.	Matrix	TOC mg C/L	Dilution Factor
96-3151-01	MW-38	Water	1.7	1
96-3151-01 Dup	MW-38 Dup	Water	2.0	1
96-3151-03	ECS-31	Water	2.7	1
Method Blank	(9/19/96)		<1.0	

Quality Assurance

		Spike Amount (mgC/L)	Sample Result (mgC/L)	Spike Result (mgC/L)	% Recovery
96-3151-01	MW-38 Matrix Spike	10.0	1.7	13.7	120
96-3151-01	MW-38 Matrix Spike Dup	10.0	1.7	12.6	109
MS/MSD RPD					9.6

Analyst

Approved

SEP 24 1996

CUSTOMER #:
02604

HUFFMAN

LABORATORIES, INC.

Quality Analytical Services Since 1936

4630 Indiana Street • Golden, CO 80403
Phone: (303) 278-4455 • FAX: (303) 278-7012

DATE 9/23/96
LAB# 206796
P.O. 13380
RECD 09/19/96

ANALYSIS REPORT

PATTY MC CLELLEN
EVERGREEN ANALYTICAL, INC
4036 YOUNGFIELD STREET
WHEAT RIDGE CO 80033

SEQUENCE/ SAMPLE NUMBER	ANALYSIS CARBONATE C---%	TOTAL CARBON--%	ORGANIC C-----%	EAL Sample#	% moisture	Dry weight basis
01/MP-1	<0.02	<0.05	<0.05	-3151-05	17.57	<0.06
02/MP-3	<0.02	<0.05	<0.05	-3185-04	3.24	<0.05
03/MP-4	<0.02	<0.05	<0.05	-3185-05	17.30	<0.06
04/SS-1	<0.02	<0.05	<0.05	-3185-10	5.04	<0.05
05/MP-6	<0.02	<0.05	<0.05	-3185-12	5.15	<0.05
06/MP-2	<0.02	0.50	0.50	-3185-13	10.24	0.55
07/MP-10	<0.02	<0.05	<0.05	-3235-13	6.62	<0.05
08/MP-11	<0.02	<0.05	<0.05	-3252-06	15.32	<0.06
09/MP-14	<0.02	<0.05	<0.05	-3252-07	10.84	<0.06
10/SS-2	<0.02	0.18	0.18	-3252-17	9.54	0.20
11/SS-3	<0.02	<0.05	<0.05	3252-18	4.06	<0.05
12/SS-4	<0.02	0.21	0.21	-3252-19	9.49	0.23
13/SS-5 (12')	<0.02	<0.05	<0.05	-3252-22	6.30	<0.05

SEP 2 4 1996

CUSTOMER #:
02604

HUFFMAN

LABORATORIES, INC.

Quality Analytical Services Since 1936

4630 Indiana Street • Golden, CO 80403
Phone: (303) 278-4455 • FAX: (303) 278-7012

DATE 9/23/96
LAB# 20679
P.O. 1338
RECD 09/19/96

ANALYSIS REPORT

PATTY MC CLELLEN
EVERGREEN ANALYTICAL, INC
4036 YOUNGFIELD STREET
WHEAT RIDGE CO 80033

SEQUENCE/ SAMPLE NUMBER	ANALYSIS CARBONATE C---%	TOTAL CARBON--%	ORGANIC C-----%
01/MP-1	<0.02	<0.05	<0.05
02/MP-3	<0.02	<0.05	<0.05
03/MP-4	<0.02	<0.05	<0.05
04/SS-1	<0.02	<0.05	<0.05
05/MP-6	<0.02	<0.05	<0.05
06/MP-2	<0.02	0.50	0.50
07/MP-10	<0.02	<0.05	<0.05
08/MP-11	<0.02	<0.05	<0.05
09/MP-14	<0.02	<0.05	<0.05
10/SS-2	<0.02	0.18	0.18
11/SS-3	<0.02	<0.05	<0.05
12/SS-4	<0.02	0.21	0.21
13/SS-5 (12′)	<0.02	<0.05	<0.05

Evergreen Analytical, Inc.

96-3185

WORK ORDER Summary

16-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 72969.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3185-04A	MP-3	% Moisture for dry weight calculation		Soil	Out	11-Sep-96	12-Sep-96	26-Sep-96	09-Oct-96
96-3185-05A	MP-4	% Moisture for dry weight calculation						26-Sep-96	09-Oct-96
96-3185-10A	SS-1	% Moisture for dry weight calculation			2			26-Sep-96	09-Oct-96
96-3185-12A	MP-6	% Moisture for dry weight calculation			Out			26-Sep-96	09-Oct-96
96-3185-13A	MP-2	% Moisture for dry weight calculation			A6/Ou	10-Sep-96		26-Sep-96	08-Oct-96
96-3185-01D	CEA-2	Anions by IC Cl,NO2,NO3,SO4		Water	A6			26-Sep-96	12-Sep-96
96-3185-02D	MW-37	Anions by IC Cl,NO2,NO3,SO4				11-Sep-96		26-Sep-96	13-Sep-96
96-3185-03D	MW-39	Anions by IC Cl,NO2,NO3,SO4						26-Sep-96	13-Sep-96
96-3185-06D	ECS-30	Anions by IC Cl,NO2,NO3,SO4						26-Sep-96	13-Sep-96
96-3185-07D	MW-10	Anions by IC Cl,NO2,NO3,SO4						26-Sep-96	13-Sep-96
96-3185-08D	MW-11	Anions by IC Cl,NO2,NO3,SO4						26-Sep-96	13-Sep-96
96-3185-11G	ECS-24	Anions by IC Cl,NO2,NO3,SO4						26-Sep-96	13-Sep-96
96-3185-01A	CEA-2	BTEX + TVPH (Parsons List)			2	10-Sep-96		26-Sep-96	24-Sep-96
96-3185-02A	MW-37	BTEX + TVPH (Parsons List)				11-Sep-96		26-Sep-96	25-Sep-96
96-3185-03A	MW-39	BTEX + TVPH (Parsons List)						26-Sep-96	25-Sep-96
96-3185-06A	ECS-30	BTEX + TVPH (Parsons List)						26-Sep-96	25-Sep-96
96-3185-07A	MW-10	BTEX + TVPH (Parsons List)						26-Sep-96	25-Sep-96
96-3185-08A	MW-11	BTEX + TVPH (Parsons List)						26-Sep-96	25-Sep-96

# = Special list. See sample comments or test information.
HT = Holding Time expiration date.

9/16/96

Evergreen Analytical, Inc.

WORK ORDER Summary

16-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 72969.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3185-10A	SS-1	BTEX + TVPH (Parsons List)		Soil	2	11-Sep-96	12-Sep-96	26-Sep-96	18-Sep-96
96-3185-11A	ECS-24	BTEX + TVPH (Parsons List)		Water				26-Sep-96	25-Sep-96
96-3185-13A	MP-2	BTEX + TVPH (Parsons List)		Soil	A6/Ou	10-Sep-96		26-Sep-96	17-Sep-96
96-3185-09A	Trip Blank	BTEX / TVPH Combo		Water	2	11-Sep-96		26-Sep-96	25-Sep-96
96-3185-01E	CEA-2	Methane				10-Sep-96		26-Sep-96	24-Sep-96
96-3185-02E	MW-37	Methane				11-Sep-96		26-Sep-96	25-Sep-96
96-3185-03E	MW-39	Methane						26-Sep-96	25-Sep-96
96-3185-06E	ECS-30	Methane						26-Sep-96	25-Sep-96
96-3185-07E	MW-10	Methane						26-Sep-96	25-Sep-96
96-3185-08E	MW-11	Methane						26-Sep-96	25-Sep-96
96-3185-11D	ECS-24	Methane						26-Sep-96	25-Sep-96
96-3185-13A	MP-2	Sample required splitting.		Soil	A6/Ou	10-Sep-96		26-Sep-96	17-Sep-96
96-3185-07H	MW-10	Total Alkalinity		Water	A6	11-Sep-96		26-Sep-96	25-Sep-96
96-3185-04A	MP-3	Total Organic Carbon		Soil	Out			26-Sep-96	18-Sep-96
96-3185-05A	MP-4	Total Organic Carbon						26-Sep-96	18-Sep-96
96-3185-10B	SS-1	Total Organic Carbon						26-Sep-96	18-Sep-96
96-3185-12A	MP-6	Total Organic Carbon						26-Sep-96	18-Sep-96
96-3185-13A	MP-2	Total Organic Carbon Out			A6/Ou	10-Sep-96		26-Sep-96	17-Sep-96

# = Sp[illegible]list. See sample comments or test information.
HT = [illegible]g Time expiration date.

CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

Page 1 of ____

COMPANY Parsons ES
ADDRESS 1700 Broadway Suite 900
CITY Denver STATE CO ZIP 80290
PHONE# 303 831 8100 FAX # 303 831 8208

Evergreen Analytical Inc.
4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400
FAX RESULTS Y / N

CLIENT CONTACT (print) Dave Moutoux
CLIENT PROJ. I.D. Westover ~~AFB~~ ARB
EAL. QUOTE # ____ P.O.# ____
TURNAROUND REQUIRED* ☐ STD (2 wks) ☐ UST ☐ Other (Specify)* ____
*expedited turnaround subject to additional fee

Sampler Name:
(signature) Saskia Hoffer
(print) Saskia Hoffer

Please **PRINT** all information:

EAL use only — Do not write in shaded area
W.O. # 96-3185
B.O.F. # 467
C/S (O) #1 / CO
C/S (I) #1 / CO
Cooler Temp. °C 9 Cooler
Seals Intact Y / N / NA Taped
Samples Pres. Y / N / NA
Headspace Y / N / NA

CLIENT SAMPLE IDENTIFICATION	DATE SAMPLED	TIME	No. of Containers	Water-Drinking/Discharge/Ground (circle)	Soil / Solid / Air / Gas	Oil / Sludge / Multi-phase	TCLP VOA/BNA/Pest/Herb/Metals (circle)	VOA 8260/624/524.2 (circle)	BNA 8270/625 (circle)	Pesticides 8080/608 (circle)	Pest/PCBs 8080/608/508 (circle)	PCB Screen	Herbicides 8150/515 (circle)	BTEX 8020/602 (circle)/MTBE (circle)	TVPH 8015mod. (Gasoline)	TEPH 8015mod. (Diesel)	Total Metals-DW / NPDES / SW846 (circle & list metals below)	Dissolved Metals - DW / SW846 (circle & list metals below)	Oil & Grease 413.1	TRPH 418.1	Cl⁻, NO2, NO3, SO4	Methane	Alkalinity	TOC		EAL use only
CEA-2	9/10/96	1730	7	X										X	X						X	X				01 A-G
MW-37	9/11/96	0930	7	X										X	X						X	X				02 A-G
MW-39	9/11/96	1045	7	X										X	X						X	X				03 A-G
MP-3	9/11/96	9:10	1		X																			X		04 A 2WM
MP-4	9/11/96	10:00	1		X																			X		05 A 2WM
ECS-30	9/11/96	1200	7	X	~~X~~									X	X						X	X				06 A-G
MW-10	9/11/96	1430	8	X										X	X						X	X	X			07 A-H
MW-11	9/11/96	1515	7	X										X	X						X	X				08 A-G
Trip Blank	9/11/96	—	1	X										X	X											~~9~~ 09 A
SS-1	9/11/96	2:30	2		X									X	X									X		10 A/B 4WM/2WM
Sample Fraction														A-C							D	E-G	H			Loc 2, A6, OUT
Instructions:														40V							125 P	40 V	250 P			Cont ←

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Saskia Hoffer	1700 9/11	FEDEX	5:00 pm 9/11			[signature]	9/12/96 0920

CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

Evergreen Analytical Inc.
4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

COMPANY SAA
ADDRESS
CITY ____ STATE ____ ZIP ____
PHONE# ____ FAX # ____ FAX RESULTS Y / N

CLIENT CONTACT (print) SAA
CLIENT PROJ. I.D.
EAL. QUOTE # ____ P.O.# ____
TURNAROUND REQUIRED* ☐ STD (2 wks) ☐ UST ☐ Other (Specify)* ____
*expedited turnaround subject to additional fee

Sampler Name:
(signature) Saskia Hoffer
(print) Saskia Hoffer

Please **PRINT** all information:

CLIENT SAMPLE IDENTIFICATION	DATE SAMPLED	TIME	No. of Containers	MATRIX: Water-Drinking/Discharge/Ground (circle)	MATRIX: Soil / Solid / Air / Gas	MATRIX: Oil / Sludge / Multi-phase	TCLP VOA/BNA/Pest/Herb/Metals (circle)	VOA 8260/624/524.2 (circle)	BNA 8270/625 (circle)	Pesticides 8080/608 (circle)	Pest/PCBs 8080/608/508 (circle)	PCB Screen	Herbicides 8150/515 (circle)	BTEX 8020/602 (circle)/MTBE (circle)	TVPH 8015mod. (Gasoline)	TEPH 8015mod. (Diesel)	Total Metals-DW / NPDES / SW846 (circle & list metals below)	Dissolved Metals - DW / SW846 (circle & list metals below)	Oil & Grease 413.1	TRPH 418.1	Methane	Alkalinity	TOC	Cl⁻, NO_2, NO_3, $SO_4^=$			EAL use only
ECS-24	9/11/96	1630	7	X										Y	X						X			X			11A-G
MP-6	9/11/96	1620	1	~~X~~	X																		X				12A 2wm
MP-2	9/10/96	17:15	2		X									X	X								X				13A~~/B~~ 4wm
																											2nd jar
																											MP-2 not
																											rec'd -
																											mpm
																											9/12/96
Sample Fraction														A/c							D-F			G			Loc
Instructions:																											Cont

EAL use only / Do not write in shaded area
W.O. # 96-3185
B.O.F. #
C/S (O)
C/S (I)
Cooler Temp. °C See P. 1
Seals Intact Y / N / NA
Samples Pres. Y / N / NA
Headspace Y / N / NA

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Saskia Hoffer	9/11	FEDEX	9/11			M. Mead	9/12/96 0920

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB1091396	Client Project Number	: Westover ARB
Date Prepared	: 9/13/96	Lab Project Number	: 96-3185
Dilution Factor	: 1.0	Matrix	: WATER
		Lab File Number	: TVB10912035

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/13/96	U	0.1	mg/L
Benzene	71-43-2	9/13/96	U	0.4	ug/L
Toluene	108-88-3	9/13/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/13/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/13/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/13/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/13/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/13/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/13/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/13/96	U	0.5	ug/L
FID Surrogate Recovery:		100%		70%-130%	(Limits)
PID Surrogate Recovery:		103%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB1091696	Client Project Number	: Westover ARB
Date Prepared	: 9/16/96	Lab Project Number	: 96-3185
Dilution Factor	: 1.0	Matrix	: WATER
		Lab File Number	: TVB10916005

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	U	0.1	mg/L
Benzene	71-43-2	9/16/96	U	0.4	ug/L
Toluene	108-88-3	9/16/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/16/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/16/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/16/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/16/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/16/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/16/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/16/96	U	0.5	ug/L
FID Surrogate Recovery:		101%		70%-130%	(Lim
PID Surrogate Recovery:		103%		70%-128%	(Lim

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:
E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Holman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB1091796B	Client Project Number	: Westover ARB
Date Prepared	: 9/17/96	Lab Project Number	: 96-3185
Dilution Factor	: 1.0	Matrix	: WATER
		Lab File Number	: TVB10916035

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	U	0.1	mg/L
Benzene	71-43-2	9/17/96	U	0.4	ug/L
Toluene	108-88-3	9/17/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	U	0.5	ug/L
FID Surrogate Recovery:		99%		70%-130%	(Limits)
PID Surrogate Recovery:		102%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	CEA-2	Client Project Number	:	Westover ARB
Lab Sample Number	:	96-3185-01	Lab Project Number	:	96-3185
Date Sampled	:	9/10/96	Matrix	:	WATER
Date Received	:	9/12/96	Lab File Number(s)	:	TVB10916012
Date Prepared	:	9/16/96	Method Blank	:	MB1091696
FID Dilution Factor	:	50			
PID Dilution Factor	:	50			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	U	5.0	mg/L
Benzene	71-43-2	9/16/96	U	20	ug/L
Toluene	108-88-3	9/16/96	1000	20	ug/L
Chlorobenzene	108-90-7	9/16/96	640	20	ug/L
Ethyl Benzene	100-41-4	9/16/96	640	20	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/16/96	3200	20	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/16/96	110	20	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/16/96	380	20	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/16/96	130	20	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/16/96	U	25	ug/L
FID Surrogate Recovery:		97%		70%-130%	(Lim
PID Surrogate Recovery:		97%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Bleaha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	MW-37	Client Project Number	:	Westover ARB
Lab Sample Number	:	96-3185-02	Lab Project Number	:	96-3185
Date Sampled	:	9/11/96	Matrix	:	WATER
Date Received	:	9/12/96	Lab File Number(s)	:	TVB10916013
Date Prepared	:	9/16/96	Method Blank	:	MB1091696
FID Dilution Factor	:	1.0			
PID Dilution Factor	:	1.0			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	U	0.1	mg/L
Benzene	71-43-2	9/16/96	U	0.4	ug/L
Toluene	108-88-3	9/16/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/16/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/16/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/16/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/16/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/16/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/16/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/16/96	U	0.5	ug/L
FID Surrogate Recovery:		98%		70%-130%	(Limits)
PID Surrogate Recovery:		100%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-39	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3185-03	Lab Project Number	: 96-3185
Date Sampled	: 9/11/96	Matrix	: WATER
Date Received	: 9/12/96	Lab File Number(s)	: TVB10916019
Date Prepared	: 9/16/96	Method Blank	: MB1091696
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	U	0.1	mg/L
Benzene	71-43-2	9/16/96	U	0.4	ug/L
Toluene	108-88-3	9/16/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/16/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/16/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/16/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/16/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/16/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/16/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/16/96	U	0.5	ug/L
FID Surrogate Recovery:		99%		70%-130%	(Lim
PID Surrogate Recovery:		104%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: ECS-30	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3185-06	Lab Project Number	: 96-3185
Date Sampled	: 9/11/96	Matrix	: WATER
Date Received	: 9/12/96	Lab File Number(s)	: TVB10916020,36
Date Prepared	: 9/16,17/1996	Method Blanks	: MB1091696, MB1091796B
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0,10		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	2.2	0.1	mg/L
Benzene	71-43-2	9/16/96	30	0.4	ug/L
Toluene	108-88-3	9/17/96	350	4.0	ug/L
Chlorobenzene	108-90-7	9/16/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/16/96	58	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/16/96	130	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/16/96	8.5	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/16/96	23	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/16/96	14	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/16/96	1.3	0.5	ug/L
FID Surrogate Recovery:		97%		70%-130%	(Limits)
PID Surrogate Recovery:		99%,103%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-10	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3185-07	Lab Project Number	: 96-3185
Date Sampled	: 9/11/96	Matrix	: WATER
Date Received	: 9/12/96	Lab File Number(s)	: TVB10916037,41
Date Prepared	: 9/17/96	Method Blank	: MB1091796B
FID Dilution Factor	: 10		
PID Dilution Factor	: 10,100		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	18	1.0	mg/L
Benzene	71-43-2	9/17/96	1800	40	ug/L
Toluene	108-88-3	9/17/96	5500	40	ug/L
Chlorobenzene	108-90-7	9/17/96	U	4.0	ug/L
Ethyl Benzene	100-41-4	9/17/96	550	4.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	2600	40	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	140	4.0	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	370	4.0	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	210	4.0	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	52	5.0	ug/L
FID Surrogate Recovery:		97%		70%-130%	(Limits)
PID Surrogate Recovery:		98%,104%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-11	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3185-08	Lab Project Number	: 96-3185
Date Sampled	: 9/11/96	Matrix	: WATER
Date Received	: 9/12/96	Lab File Number(s)	: TVB10916023
Date Prepared	: 9/16/96	Method Blank	: MB1091696
FID Dilution Factor	: 10		
PID Dilution Factor	: 10		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	1.5	1.0	mg/L
Benzene	71-43-2	9/16/96	U	4.0	ug/L
Toluene	108-88-3	9/16/96	500	4.0	ug/L
Chlorobenzene	108-90-7	9/16/96	U	4.0	ug/L
Ethyl Benzene	100-41-4	9/16/96	160	4.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/16/96	790	4.0	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/16/96	43	4.0	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/16/96	140	4.0	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/16/96	90	4.0	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/16/96	25	5.0	ug/L
FID Surrogate Recovery:		95%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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B = Compound also found in the blank.
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RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	TRIP BLANK	Client Project Number	:	Westover ARB
Lab Sample Number	:	96-3185-09	Lab Project Number	:	96-3185
Date Sampled	:	N/A	Matrix	:	WATER
Date Received	:	9/12/96	Lab File Number(s)	:	TVB10916024
Date Prepared	:	9/16/96	Method Blank	:	MB1091696
FID Dilution Factor	:	1.0			
PID Dilution Factor	:	1.0			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	U	0.1	mg/L
Benzene	71-43-2	9/16/96	U	0.4	ug/L
Toluene	108-88-3	9/16/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/16/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/16/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/16/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/16/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/16/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/16/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/16/96	U	0.5	ug/L
FID Surrogate Recovery:		96%		70%-130%	(Limits)
PID Surrogate Recovery:		102%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Oleska
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: SS-1	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3185-10	Lab Project Number	: 96-3185
Date Sampled	: 9/11/96	Matrix	: SOIL
Date Received	: 9/12/96	Lab File Number(s)	: TVB10912061
Date Prepared	: 9/13/96	Method Blank	: MB1091396
FID Dilution Factor	: 1.0	Soil Extracted?	: NO
PID Dilution Factor	: 1.0	Soil Moisture	: 5.04%

Compound Name	Cas Number	Analysis Date	Sample ** Concentration	RL **	Units
TVH-Gasoline	----	9/14/96	U	0.1	mg/kg
Benzene	71-43-2	9/14/96	U	0.4	ug/kg
Toluene	108-88-3	9/14/96	1.3	0.4	ug/kg
Chlorobenzene	108-90-7	9/14/96	U	0.4	ug/kg
Ethyl Benzene	100-41-4	9/14/96	U	0.4	ug/kg
Total Xylenes (m,p,o)	1330-20-7	9/14/96	1.4	0.4	ug/kg
1,3,5-Trimethylbenzene	108-67-8	9/14/96	U	0.4	ug/kg
1,2,4-Trimethylbenzene	95-63-6	9/14/96	0.8	0.4	ug/kg
1,2,3-Trimethylbenzene	526-73-8	9/14/96	U	0.4	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	9/14/96	U	0.5	ug/kg
FID Surrogate Recovery:		91%		50%-132%	(Limits)
PID Surrogate Recovery:		94%		72%-118%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: ** = Based on dry weight.

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: ECS-24	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3185-11	Lab Project Number	: 96-3185
Date Sampled	: 9/11/96	Matrix	: WATER
Date Received	: 9/12/96	Lab File Number(s)	: TVB10916025,38,42
Date Prepared	: 9/16,17/96	Method Blank	: MB1091696, MB1091796B
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 10,100		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	7.4	0.1	mg/L
Benzene	71-43-2	9/17/96	U	4.0	ug/L
Toluene	108-88-3	9/17/96	370	4.0	ug/L
Chlorobenzene	108-90-7	9/17/96	U	4.0	ug/L
Ethyl Benzene	100-41-4	9/17/96	410	4.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	2100	40	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	140	4.0	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	380	4.0	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	220	4.0	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	55	5.0	ug/L
FID Surrogate Recovery:		96%		70%-130%	(Lim
PID Surrogate Recovery:		98%,89%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-2	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3185-13	Lab Project Number	: 96-3185
Date Sampled	: 9/10/96	Matrix	: SOIL
Date Received	: 9/12/96	Lab File Number(s)	: TVB10912062
Date Prepared	: 9/13/96	Method Blank	: MB1091396
FID Dilution Factor	: 1.0	Soil Extracted?	: NO
PID Dilution Factor	: 1.0	Soil Moisture	: 10.24%

Compound Name	Cas Number	Analysis Date	Sample** Concentration	RL**	Units
TVH-Gasoline	----	9/14/96	U	0.1	mg/kg
Benzene	71-43-2	9/14/96	U	0.4	ug/kg
Toluene	108-88-3	9/14/96	0.5	0.4	ug/kg
Chlorobenzene	108-90-7	9/14/96	U	0.4	ug/kg
Ethyl Benzene	100-41-4	9/14/96	U	0.4	ug/kg
Total Xylenes (m,p,o)	1330-20-7	9/14/96	0.7	0.4	ug/kg
1,3,5-Trimethylbenzene	108-67-8	9/14/96	U	0.4	ug/kg
1,2,4-Trimethylbenzene	95-63-6	9/14/96	U	0.4	ug/kg
1,2,3-Trimethylbenzene	526-73-8	9/14/96	U	0.4	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	9/14/96	U	0.6	ug/kg
FID Surrogate Recovery:		36%	*	50%-132%	(Limits)
PID Surrogate Recovery:		70%	*	72%-118%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: * = Low Surrogate Recovery. The sample was re-analyzed with similar surrogate recovery.
** = Based on dry weight.

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

[signature]
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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: LCS1091396-GAS	Matrix	: WATER
Date Prepared	: 9/13/96	Method Numbers	: EPA 5030/8015 Modified
Date Analyzed	: 9/13/96	Instrument Name	: TVHBTEX1
Lab File Number(s)	: TVB10912048		

Compound Name	Theoretical Concentration (mg/L)	LCS Concentration (mg/L)	LCS % Recovery	QC Limit % Recovery
Gasoline	2.00	2.15	107.6	82 - 120
Surrogate Recovery:		98%		70 - 121

QUALIFIERS
B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA=Not Available/Not Applicable.
** = Limits established 8/13/96 for TVHBTEX1. MAB

M. Blecha
Analyst

K. Hollman
Approved

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EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number	: LCS1091396-BTEX	Dilution Factor	: 1.00
Date Extracted/Prepared	: 9/13/96	Method	: 602/8020
Date Analyzed	: 9/13/96	Matrix	: Water
Spike Amount (ug/L)	: 20.0	Lab File No.	: TVB10912049

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	18.0	90.0	73 - 107
Toluene	108-88-3	17.3	86.5	74 - 110
Chlorobenzene	108-90-7	16.7	83.5	67 - 106
Ethyl Benzene	100-41-4	17.7	88.5	73 - 112
m,p-Xylene	108-38-3 106-42-3	34.3	85.8	71 - 110
o-Xylene	95-47-6	18.3	91.5	72 - 115
MTBE	1634-04-4	19.6	98.0	53 - 131
1,3,5-Trimethylbenzene	108-67-8	16.2	81.0	69 - 96
1,2,4-Trimethylbenzene	95-63-6	17.1	85.5	70 - 100
1,2,3-Trimethylbenzene	526-73-8	20.9	104.5	81 - 119
1,2,3,4-Tetramethylbenzene	488-23-3	18.2	91.0	63 - 116
Surrogate Recovery:		104%		82 - 115

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:
E = Extrapolated value. Value exceeds that of the calibration range.
U = Compound analyzed for, but not detected.
B = Compound found in blank and sample. Compare blank and sample data.
NA = Not available/Not analyzed.
** = Limits updated 8/13/96 for TVHBTEX1. MAB

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Analyst

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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: LCS1091796-GAS	Matrix	: WATER
Date Prepared	: 9/17/96	Method Numbers	: EPA 5030/8015 Modified
Date Analyzed	: 9/17/96	Instrument Name	: TVHBTEX1
Lab File Number(s)	: TVB10916043		

Compound Name	Theoretical Concentration (mg/L)	LCS Concentration (mg/L)	LCS % Recovery	QC Limit % Recovery
Gasoline	2.00	1.76	87.9	82 - 120
Surrogate Recovery:		92%		70 - 121

QUALIFIERS
B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA=Not Available/Not Applicable.
** = Limits established 8/13/96 for TVHBTEX1. MAB

M. Blecha
Analyst

K. Hollman
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EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number	: LCS1091796-BTEX	Dilution Factor	: 1.00
Date Extracted/Prepared	: 9/17/96	Method	: 602/8020
Date Analyzed	: 9/17/96	Matrix	: Water
Spike Amount (ug/L)	: 20.0	Lab File No.	: TVB10916044

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	18.2	91.0	73 - 107
Toluene	108-88-3	17.9	89.5	74 - 110
Chlorobenzene	108-90-7	17.1	85.5	67 - 106
Ethyl Benzene	100-41-4	18.2	91.0	73 - 112
m,p-Xylene	108-38-3 106-42-3	35.4	88.5	71 - 110
o-Xylene	95-47-6	18.7	93.5	72 - 115
MTBE	1634-04-4	20.1	100.5	53 - 131
1,3,5-Trimethylbenzene	108-67-8	16.6	83.0	69 - 96
1,2,4-Trimethylbenzene	95-63-6	17.6	88.0	70 - 100
1,2,3-Trimethylbenzene	526-73-8	21.1	105.5	81 - 119
1,2,3,4-Tetramethylbenzene	488-23-3	18.4	92.0	63 - 116
Surrogate Recovery:		102%		82 - 115

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:
E = Extrapolated value. Value exceeds that of the calibration range.
U = Compound analyzed for, but not detected.
B = Compound found in blank and sample. Compare blank and sample data.
NA = Not available/Not analyzed.
** = Limits updated 8/13/96 for TVHBTEX1. MAB

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
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Methane Report Form
Method Blank Report

Method Blank Number	: GB091396	**Client Project No.**	: Westover ARB
Date Extracted/Prepared	: 9/13/96	**Lab Work Order**	: 96-3185
Date Analyzed	: 9/13/96	**Dilution Factor**	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS0913002

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Bill Michener
Analyst

K. Hollman
Approved

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Methane Report Form

Client Sample Number	: CEA-2	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3185-01	Lab Work Order	: 96-3185
Date Sampled	: 9/10/96	Dilution Factor	: 10.00
Date Received	: 9/12/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913011

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.65	0.02

[illegible]nperature	: 72.4 F	Saturation	Meth	0.156339173
Amount Injected	: 0.05 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.492219782
Head space created	: 4 ml	in Head Space		
Methane Area	: 363.559 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3185.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form

Client Sample Number	: MW-37	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3185-02	Lab Work Order	: 96-3185
Date Sampled	: 9/11/96	Dilution Factor	: 1.00
Date Received	: 9/12/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913012

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 72.4 F	Saturation Concentration	Meth	
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	
Head space created	: 4 ml			
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: MW-39	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3185-03	Lab Work Order	: 96-3185
Date Sampled	: 9/11/96	Dilution Factor	: 1.00
Date Received	: 9/12/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913013

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	:	72.3 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	0 ug
Atomic weight(Methane)	:	16 g

Saturation Concentration	Meth	0
Concentration in Head Space	Meth	0

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form

Client Sample Number	: ECS-30	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3185-06	Lab Work Order	: 96-3185
Date Sampled	: 9/11/96	Dilution Factor	: 1.00
Date Received	: 9/12/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913014

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.022	0.002

Temperature	: 72.3 F	Saturation Concentration	Meth 0.0052[illegible]7
Amount Injected	: 0.5 ml		
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth 0.01660807
Head space created	: 4 ml		
Methane Area	: 122.646 ug		

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: MW-10	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3185-07	Lab Work Order	: 96-3185
Date Sampled	: 9/11/96	Dilution Factor	: 1.00
Date Received	: 9/12/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913016

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.005	0.002

mperature	: 72.5 F	Saturation Concentration	Meth	0.001137371
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.003580237
Head space created	: 4 ml			
Methane Area	: 26.449 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.

U = Compound analyzed for, but not detected.

B = Compound also found in the blank.

RL = Reporting Limit.

NA = Not Available/Not Applicable.

Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form

Client Sample Number	: MW-11	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3185-08	Lab Work Order	: 96-3185
Date Sampled	: 9/11/96	Dilution Factor	: 1.00
Date Received	: 9/12/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913017

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.019	0.002

Temperature	:	72.4 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	105.819 ug
Atomic weight(Methane)	:	16 g

Saturation Concentration	Meth	0.0045[illegible]
Concentration in Head Space	Meth	0.01432675[illegible]

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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AF3185.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form

Client Sample Number	: ECS-24	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3185-11	Lab Work Order	: 96-3185
Date Sampled	: 9/11/96	Dilution Factor	: 1.00
Date Received	: 9/12/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Lab File No.	: GAS0913018

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.011	0.002

Temperature	: 72.3 F	Saturation Concentration	Meth	0.002672772
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.008416566
Head space created	: 4 ml			
Methane Area	: 62.154 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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AF3185.XLS

Evergreen Analytical, Inc.
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(303) 425-6021

RSKSOP-175M Gas Method
Methane Gas Matrix Spike / Matrix Spike Duplicate Report

Client Sample No.	: MW-39	Client Project No.	: Westover ARB
Lab Sample No.	: 96-3185-03	Lab Work Order	: 96-3185
Date Sampled	: 9/11/96	EPA Method No.	: RSKSOP-175M
Date Received	: 9/12/96	Matrix	: Water
Date Prepared	: 9/13/96	Method Blank	: GB091396
Date Analyzed	: 9/13/96	Lab File No's.	: GAS0913019,020
E.A. MS/MSD Spike Source No.	: 1886		

Compound	Spike Added (ug)	Sample Concentration (ug)	MS Concentration (ug)	MS %REC	QC Limits %REC
Methane Gas	500	0	299	60	40-89

Compound	Spike Added (ug)	MSD Concentration (ug)	MSD %REC	RPD	QC Limits RPD	QC Limits %REC
Methane Gas	500	302	60	0.8	0-24.4	40-89

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available

Note: The Spike was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Analyst

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RSKSOP-175M Gas Method
Methane LCS Report Form

LCS No.	: LCS091396	EPA Method No.	: RSKSOP-175M
Date Prepared	: 9/13/96	Matrix	: Water
Date Analyzed	: 9/13/96	Method Blank	: GB091396
E.A. LCS Source No.	: 1886	Lab File No.	: GAS0913005

Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	413	83	67-85

Spike Recovery: 0 out of (1) outside limits.

Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available.

Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

72969.28010

Date Sampled	:	9/10,11/96	Client Project ID.	:	Westover ARB
Date Received	:	9/12/96	Lab Project Number	:	96-3185
Date Prepared	:	9/12/96	Method	:	EPA 300.0
Date Analyzed	:	9/12/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride (mg/L)	Dilution Factor
96-3185-01	CEA-2	Water	11.7	1
96-3185-02	MW-37	Water	3.1	1
96-3185-03	MW-39	Water	3.6	1
96-3185-06	ECS-30	Water	4.0	1
96-3185-07	MW-10	Water	5.2	1
96-3185-08	MW-11	Water	5.8	1
96-3185-11	ESC-24	Water	4.2	1
Method Blank	(9/12/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3151-01	MW-38 Matrix Spike	10.0	7.6	16.6	89
96-3151-01	MW-38 Matrix Spike Dup	10.0	7.6	16.3	87
MS/MSD RPD					2.9

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

					72969.28010
Date Sampled	: 9/10,11/96		Client Project ID.	:	Westover ARB
Date Received	: 9/12/96		Lab Project Number	:	96-3185
Date Prepared	: 9/12/96		Method	:	EPA 300.0
Date Analyzed	: 9/12/96		Detection Limit	:	0.076 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N (mg/L)	Dilution Factor
96-3185-01	CEA-2	Water	<0.076	1
96-3185-02	MW-37	Water	<0.076	1
96-3185-03	MW-39	Water	<0.076	1
96-3185-06	ECS-30	Water	<0.076	1
96-3185-07	MW-10	Water	<0.076	1
96-3185-08	MW-11	Water	<0.076	1
96-3185-11	ESC-24	Water	<0.076	1
Method Blank	(9/12/96)		<0.076	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3151-01	MW-38 Matrix Spike	10.0	<0.25	9.4	94
96-3151-01	MW-38 Matrix Spike Dup	10.0	<0.25	9.5	95
MS/MSD RPD					0.1

* = Quality assurance results reported as Nitrite (NO_2).

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.

4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/10,11/96			72969.28010
		Client Project ID.	:	Westover ARB
Date Received	: 9/12/96	Lab Project Number	:	96-3185
Date Prepared	: 9/12/96	Method	:	EPA 300.0
Date Analyzed	: 9/12/96	Detection Limit	:	0.056 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrate-N (mg/L)	Dilution Factor
96-3185-01	CEA-2	Water	0.12	1
96-3185-02	MW-37	Water	3.8	1
96-3185-03	MW-39	Water	0.88	1
96-3185-06	ECS-30	Water	0.62	1
96-3185-07	MW-10	Water	0.14	1
96-3185-08	MW-11	Water	1.46	1
96-3185-11	ESC-24	Water	1.1	1
Method Blank	(9/12/96)		<0.056	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3151-01	MW-38 Matrix Spike	10.0	15.3	25.4	100
96-3151-01	MW-38 Matrix Spike Dup	10.0	15.3	25.6	102
MS/MSD RPD					2.0

* = Quality assurance results reported as Nitrate (NO_3).

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

					72969.28010
Date Sampled	:	9/10,11/96	Client Project ID.	:	Westover ARB
Date Received	:	9/12/96	Lab Project Number	:	96-3185
Date Prepared	:	9/12/96	Method	:	EPA 300.0
Date Analyzed	:	9/12/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Sulfate (mg/L)	Dilution Factor
96-3185-01	CEA-2	Water	6.8	1
96-3185-02	MW-37	Water	4.5	1
96-3185-03	MW-39	Water	6.9	1
96-3185-06	ECS-30	Water	4.3	1
96-3185-07	MW-10	Water	1.8	1
96-3185-08	MW-11	Water	6.1	1
96-3185-11	ESC-24	Water	10.3	1
Method Blank	(9/12/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3151-01	MW-38 Matrix Spike	10.0	12.3	22.1	99
96-3151-01	MW-38 Matrix Spike Dup	10.0	12.3	21.9	96
MS/MSD RPD					2.2

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Analysis Report

Date Sampled	: 9/11/96	Client Project ID.	: Westover ARB
Date Received	: 9/11/96	Lab Project Number	: 96-3185
Date Prepared	: 9/12/96	Method	: EPA 310.1
Date Analyzed	: 9/12/96	Detection Limit	: 5.0 mg $CaCO_3$/L

Evergreen Sample #	Client Sample ID.	Matrix	Total Alkalinity (mg $CaCO_3$/L)
96-3185-07	MW-10	Water	101
96-3185-07 Duplicate	MW-10	Water	101
Method Blank			<5.0

Quality Assurance

Reference	True Value (mg$CaCO_3$/L)	Result (mg$CaCO_3$/L)	% Recovery
ERA Minerals Lot #9970	180	184	102

Analyst

Approved

SEP 24 1996

CUSTOMER #:
02604

HUFFMAN

LABORATORIES, INC.

Quality Analytical Services Since 1936

4630 Indiana Street • Golden, CO 80403
Phone: (303) 278-4455 • FAX: (303) 278-7012

DATE 9/23/96
LAB# 206796
P.O. 13380
RECD 09/19/96

ANALYSIS REPORT

PATTY MC CLELLEN
EVERGREEN ANALYTICAL, INC
4036 YOUNGFIELD STREET
WHEAT RIDGE CO 80033

SEQUENCE/ SAMPLE NUMBER	ANALYSIS CARBONATE C---%	TOTAL CARBON--%	ORGANIC C-----%	EAL Sample#	% moisture	Dry weight basis
01/MP-1	<0.02	<0.05	<0.05	-3151-05	17.57	<0.06
02/MP-3	<0.02	<0.05	<0.05	-3185-04	3.24	<0.05
03/MP-4	<0.02	<0.05	<0.05	-3185-05	17.30	<0.06
[illegible]SS-1	<0.02	<0.05	<0.05	-3185-10	5.04	<0.05
05/MP-6	<0.02	<0.05	<0.05	-3185-12	5.15	<0.05
06/MP-2	<0.02	0.50	0.50	-3185-13	10.24	0.55
07/MP-10	<0.02	<0.05	<0.05	-3235-13	6.62	<0.05
08/MP-11	<0.02	<0.05	<0.05	-3252-06	15.32	<0.06
09/MP-14	<0.02	<0.05	<0.05	-3252-07	10.84	<0.06
10/SS-2	<0.02	0.18	0.18	-3252-17	9.54	0.20
11/SS-3	<0.02	<0.05	<0.05	3252-18	4.06	<0.05
12/SS-4	<0.02	0.21	0.21	-3252-19	9.49	0.23
13/SS-5 (12')	<0.02	<0.05	<0.05	-3252-22	6.30	<0.05

Evergreen Analytical, Inc.

96-3213

WORK ORDER Summary

17-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3213-06A	MP-8	BTEX + TVPH (Parsons List)		Water	2	12-Sep-96	13-Sep-96	27-Sep-96	26-Sep-96
96-3213-07A	MP-3	BTEX + TVPH (Parsons List)						27-Sep-96	26-Sep-96
96-3213-08A	MP-4	BTEX + TVPH (Parsons List)						27-Sep-96	26-Sep-96
96-3213-09A	MP-5(S)	BTEX + TVPH (Parsons List)						27-Sep-96	26-Sep-96
96-3213-10A	MP-5(D)	BTEX + TVPH (Parsons List)						27-Sep-96	26-Sep-96
96-3213-11A	ECS-27	BTEX + TVPH (Parsons List)						27-Sep-96	26-Sep-96
96-3213-12A	ECS-26	BTEX + TVPH (Parsons List)						27-Sep-96	26-Sep-96
96-3213-04A	Trip Blank	BTEX / TVPH Combo						27-Sep-96	
96-3213-01D	CEA-5	Methane				11-Sep-96		27-Sep-96	25-Sep-96
96-3213-02D	ECS-29	Methane				12-Sep-96		27-Sep-96	26-Sep-96
96-3213-03D	MP-1	Methane						27-Sep-96	26-Sep-96
96-3213-05D	MP-7	Methane						27-Sep-96	26-Sep-96
96-3213-06D	MP-8	Methane						27-Sep-96	26-Sep-96
96-3213-07D	MP-3	Methane						27-Sep-96	26-Sep-96
96-3213-08D	MP-4	Methane						27-Sep-96	26-Sep-96
96-3213-09D	MP-5(S)	Methane						27-Sep-96	26-Sep-96
96-3213-10D	MP-5(D)	Methane						27-Sep-96	26-Sep-96
96-3213-11D	ECS-27	Methane						27-Sep-96	26-Sep-96
96-3213-12D	ECS-26	Methane						27-Sep-96	26-Sep-96
96-3213-10H	MP-5(D)	Purgeable Halocarbons 8010			9			27-Sep-96	26-Sep-96
96-3213-02H	ECS-29	Total Alkalinity			CL3			27-Sep-96	26-Sep-96
96-3213-11H	ECS-27	Total Alkalinity						27-Sep-96	26-Sep-96
96-3213-12H	ECS-26	Total Alkalinity						27-Sep-96	26-Sep-96

PH

# = Special list. See sample comments or test information.
HT = Holding Time expiration date.

Evergreen Analytical, Inc.

96-3213

WORK ORDER Summary

17-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3213-01G	CEA-5	Anions by IC Cl,NO2,NO3,SO4		Water	CL2	11-Sep-96	13-Sep-96	27-Sep-96	13-Sep-96
96-3213-02G	ECS-29	Anions by IC Cl,NO2,NO3,SO4				12-Sep-96		27-Sep-96	14-Sep-96
96-3213-03G	MP-1	Anions by IC Cl,NO2,NO3,SO4						27-Sep-96	14-Sep-96
96-3213-05G	MP-7	Anions by IC Cl,NO2,NO3,SO4						27-Sep-96	14-Sep-96
96-3213-06G	MP-8	Anions by IC Cl,NO2,NO3,SO4						27-Sep-96	14-Sep-96
96-3213-07G	MP-3	Anions by IC Cl,NO2,NO3,SO4						27-Sep-96	14-Sep-96
96-3213-08G	MP-4	Anions by IC Cl,NO2,NO3,SO4						27-Sep-96	14-Sep-96
96-3213-09G	MP-5(S)	Anions by IC Cl,NO2,NO3,SO4						27-Sep-96	14-Sep-96
96-3213-10G	MP-5(D)	Anions by IC Cl,NO2,NO3,SO4						27-Sep-96	14-Sep-96
96-3213-11G	ECS-27	Anions by IC Cl,NO2,NO3,SO4						27-Sep-96	14-Sep-96
96-3213-12G	ECS-26	Anions by IC Cl,NO2,NO3,SO4						27-Sep-96	14-Sep-96
96-3213-01A	CEA-5	BTEX + TVPH (Parsons List)			2	11-Sep-96		27-Sep-96	25-Sep-96
96-3213-02A	ECS-29	BTEX + TVPH (Parsons List)				12-Sep-96		27-Sep-96	26-Sep-96
96-3213-03A	MP-1	BTEX + TVPH (Parsons List)						27-Sep-96	26-Sep-96
96-3213-05A	MP-7	BTEX + TVPH (Parsons List)						27-Sep-96	26-Sep-96

pH

# = Sp[illegible] list. See sample comments or test information.
HT = [illegible]ng Time expiration date.

[illegible] 9/17/96

Evergreen Analytical, Inc. **96-3213**

WORK ORDER Summary

17-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3213-11I	ECS-27	Total Organic Carbon		Water	CL3	12-Sep-96	13-Sep-96	27-Sep-96	10-Oct-96

# = Special list. See sample comments or test information.
HT = Holding Time expiration date.

CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

Page 1 of ____

Evergreen Analytical Inc.
4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

COMPANY Parsons ES
ADDRESS 1700 Broadway S. 900
CITY Denver STATE CO ZIP 80290
PHONE# 303-831-8100 FAX # 831-8209 FAX RESULTS Y / N

CLIENT CONTACT (print) Dave Moutoux
CLIENT PROJ. I.D. 729691, 280rD
EAL. QUOTE # ____ P.O.# ____
TURNAROUND REQUIRED* ☐ STD (2 wks) ☐ UST
☐ Other (Specify)* ____
*expedited turnaround subject to additional fee

Sampler Name:
(signature) Sascia Hofert
(print) Sascia Hofer

Please **PRINT** all information:

EAL use only
Do not write in shaded area
W.O. # 96.3213
B.O.F. # NA
C/S (O) NA / NA
C/S (I) NA / 6
Cooler Temp. °C 14
Seals Intact Y / N / NA (Y circled)
Samples Pres. Y / N / NA (Y circled)
Headspace Y / N / NA (N circled)

CLIENT SAMPLE IDENTIFICATION	DATE SAMPLED	TIME	No. of Containers	MATRIX: Water-Drinking/Discharge/Ground (circle)	MATRIX: Soil / Solid / Air / Gas	MATRIX: Oil / Sludge / Multi-phase	TCLP VOA/BNA/Pest/Herb/Metals (circle)	VOA 8260/624/524.2 (circle)	BNA 8270/625 (circle)	Pesticides 8080/608 (circle)	Pest/PCBs 8080/608/508 (circle)	PCB Screen	Herbicides 8150/515 (circle)	BTEX 8020/602 (circle)/MTBE (circle)	TVPH 8015mod. (Gasoline)	TEPH 8015mod. (Diesel)	Total Metals-DW / NPDES / SW846 (circle & list metals below)	Dissolved Metals - DW / SW846 (circle & list metals below)	Oil & Grease 413.1	TRPH 418.1	Anions Cl SO4 NO2 NO3	TOC	Alkalinity	Methane	8010 VOC's		EAL use only
CEA-5	9/11/96	18:00	7	X										X	X						X			X			01 A-G
ECS-29	9/12/96	830	8	X										X	X						X		X	X			02 A-H
MP-1	9/12/96	945	7	X										X	X						X			X			03 A-G
Trip Blank	-	-	~~1~~	X										X	X												04 A
MP-7	9/12/96	1045	7	X										X	X						X			X			05 A-G
MP-8	9/12/96	11:45	7	X										X	X						X			X			06 A-G
MP-3	9/12/96	13:30	7	X										X	X						X			X			07 A-G
MP-4	9/12/96	14:00	7	X										X	X						X			X			08 A-G
MP-5(S)	9/12/96	14:45	7	X										X	X						X			X			09 A-G
MP-5(D)	9/12/96	14:50	9	X										X	X						X			X	X		10 A-I
Sample Fraction																											Loc 1
																											Cont

Instructions: Sample MP-1, one of the Methanes, was received broken. (EAL # 03F)

A-C   6 ~~X~~ # D-F HI

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
	9/12/96	Fedex	9/12/96	Fedex			091396

CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

Evergreen Analytical Inc.
4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

COMPANY SAA
ADDRESS
CITY ______ STATE ______ ZIP ______
PHONE# ______ FAX # ______ FAX RESULTS Y / N

CLIENT CONTACT (print) SAA
CLIENT PROJ. I.D.
EAL. QUOTE # ______ P.O.# ______
TURNAROUND REQUIRED* ☐ STD (2 wks) ☐ UST
☐ Other (Specify)* ______
*expedited turnaround subject to additional fee

Sampler Name:
(signature) Sushia Hoffen
(print) SAGEIA HOFFEN

Please **PRINT** all information:

CLIENT SAMPLE IDENTIFICATION	DATE SAMPLED	TIME	No. of Containers	MATRIX: Water-Drinking/Discharge/Ground (circle)	MATRIX: Soil / Solid / Air / Gas	MATRIX: Oil / Sludge / Multi-phase	TCLP VOA/BNA/Pest/Herb/Metals (circle)	VOA 8260/624/524.2 (circle)	BNA 8270/625 (circle)	Pesticides 8080/608 (circle)	Pest/PCBs 8080/608/508 (circle)	PCB Screen	Herbicides 8150/515 (circle)	BTEX 8020/602 (circle)/MTBE (circle)	TVPH 8015mod. (Gasoline)	TEPH 8015mod. (Diesel)	Total Metals-DW / NPDES / SW846 (circle & list metals below)	Dissolved Metals - DW / SW846 (circle & list metals below)	Oil & Grease 413.1	TRPH 418.1	Anions Cl- SO4 NO2 NO3	Alkalinity	Methane	TOC			EAL use only
ECS-27	9/12/96	1530	9	X										X	X						X	X	X	X			11 A-I
ECS-26	9/12/96	1640	8	X										X	X						X	X	X				12 A-H
Sample Fraction																											Loc
Instructions:																											Cont

A-C G H D-F I

EAL use only
Do not write in shaded area
W.O. # 96-3213
B.O.F. #
C/S (O) ____/____
C/S (I) ____/____
Cooler Temp. °C
Seals Intact Y / N / NA
Samples Pres. Y / N / NA
Headspace Y / N / NA

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Sushia Hoffen	9/12 1700	FEDEX	9/12 1700			[illegible signature]	091396

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB091796	Client Project Number	: 729691.28010
Date Prepared	: 9/17/96	Lab Work Order	: 96-3213
Dilution Factor	: 1.0	Matrix	: WATER
		Lab File Number	: TVBX0916041

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	U	0.1	mg/L
Benzene	71-43-2	9/17/96	U	0.4	ug/L
Toluene	108-88-3	9/17/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	U	0.5	ug/L
FID Surrogate Recovery:		93%		70%-130%	(Limits)
PID Surrogate Recovery:		97%		70%-130%	(Limi

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

AnClelle
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB091896	Client Project Number	: 729691.28010
Date Prepared	: 9/18/96	Lab Work Order	: 96-3213
Dilution Factor	: 1.0	Matrix	: WATER
		Lab File Number	: TVBX0916081

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/18/96	U	0.1	mg/L
Benzene	71-43-2	9/18/96	U	0.4	ug/L
Toluene	108-88-3	9/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/18/96	U	0.5	ug/L
FID Surrogate Recovery:		92%		70%-130%	(Limits)
PID Surrogate Recovery:		98%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:
E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	CEA-5	Client Project Number	:	729691.28010
Lab Sample Number	:	96-3213-01	Lab Work Order	:	96-3213
Date Sampled	:	9/11/96	Matrix	:	WATER
Date Received	:	9/13/96	Lab File Number(s)	:	TVBX0916077,84
Date Prepared	:	9/17,18/96	Method Blank	:	MB091796, MB091896
FID Dilution Factor	:	10			
PID Dilution Factor	:	10 & 100			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	27	1.0	mg/L
Benzene	71-43-2	9/17/96	41	4.0	ug/L
Toluene	108-88-3	9/18/96	11000	40	ug/L
Chlorobenzene	108-90-7	9/17/96	U	4.0	ug/L
Ethyl Benzene	100-41-4	9/17/96	760	4.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	3800	40	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	4.0	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	210	4.0	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	61	4.0	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	U	5.0	ug/L
FID Surrogate Recovery:		90%		70%-130%	(Limits)
PID Surrogate Recovery:		95%,94%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

P. McClell
Approved

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4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: ECS-29	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3213-02	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Matrix	: WATER
Date Received	: 9/13/96	Lab File Number(s)	: TVBX0916048
Date Prepared	: 9/17/96	Method Blank	: MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	U	0.1	mg/L
Benzene	71-43-2	9/17/96	U	0.4	ug/L
Toluene	108-88-3	9/17/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	U	0.5	ug/L
FID Surrogate Recovery:		90%		70%-130%	(Limits)
PID Surrogate Recovery:		98%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-1	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3213-03	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Matrix	: WATER
Date Received	: 9/13/96	Lab File Number(s)	: TVBX0916049
Date Prepared	: 9/17/96	Method Blank	: MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	1.7	0.1	mg/L
Benzene	71-43-2	9/17/96	30	0.4	ug/L
Toluene	108-88-3	9/17/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	50	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	110	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	72	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	57	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	U	0.5	ug/L
FID Surrogate Recovery:		91%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: TRIP BLANK	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3213-04	Lab Work Order	: 96-3213
Date Sampled	: NA	Matrix	: WATER
Date Received	: 9/13/96	Lab File Number(s)	: TVBX0916076
Date Prepared	: 9/17/96	Method Blank	: MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/18/96	U	0.1	mg/L
Benzene	71-43-2	9/18/96	U	0.4	ug/L
Toluene	108-88-3	9/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/18/96	U	0.5	ug/L
FID Surrogate Recovery:		92%		70%-130%	(Limits)
PID Surrogate Recovery:		97%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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EVERGREEN ANALYTICAL, INC.
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(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-7	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3213-05	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Matrix	: WATER
Date Received	: 9/13/96	Lab File Number(s)	: TVBX0916050
Date Prepared	: 9/17/96	Method Blank	: MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	0.3	0.1	mg/L
Benzene	71-43-2	9/17/96	110	0.4	ug/L
Toluene	108-88-3	9/17/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	2.4	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	1.1	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	1.2	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	9.2	0.5	ug/L
FID Surrogate Recovery:		84%		70%-130%	(Lim
PID Surrogate Recovery:		97%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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EVERGREEN ANALYTICAL, INC.
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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-8	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3213-06	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Matrix	: WATER
Date Received	: 9/13/96	Lab File Number(s)	: TVBX0916069
Date Prepared	: 9/17/96	Method Blank	: MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/18/96	1.5	0.1	mg/L
Benzene	71-43-2	9/18/96	49	0.4	ug/L
Toluene	108-88-3	9/18/96	16	0.4	ug/L
Chlorobenzene	108-90-7	9/18/96	0.8	0.4	ug/L
Ethyl Benzene	100-41-4	9/18/96	22	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	29	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/18/96	3.7	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/18/96	8.3	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/18/96	13	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/18/96	2.6	0.5	ug/L
FID Surrogate Recovery:		89%		70%-130%	(Limits)
PID Surrogate Recovery:		94%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Holliman
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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-3	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3213-07	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Matrix	: WATER
Date Received	: 9/13/96	Lab File Number(s)	: TVBX0916070
Date Prepared	: 9/17/96	Method Blank	: MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/18/96	U	0.1	mg/L
Benzene	71-43-2	9/18/96	U	0.4	ug/L
Toluene	108-88-3	9/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/18/96	U	0.5	ug/L
FID Surrogate Recovery:		91%		70%-130%	(Lim
PID Surrogate Recovery:		97%		70%-130%	(Lim

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-4	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3213-08	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Matrix	: WATER
Date Received	: 9/13/96	Lab File Number(s)	: TVBX0916071
Date Prepared	: 9/17/96	Method Blank	: MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/18/96	U	0.1	mg/L
Benzene	71-43-2	9/18/96	U	0.4	ug/L
Toluene	108-88-3	9/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/18/96	U	0.5	ug/L
FID Surrogate Recovery:		91%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Analyst

P. McCall
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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-5(S)	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3213-09	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Matrix	: WATER
Date Received	: 9/13/96	Lab File Number(s)	: TVBX0916072
Date Prepared	: 9/17/96	Method Blank	: MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/18/96	U	0.1	mg/L
Benzene	71-43-2	9/18/96	U	0.4	ug/L
Toluene	108-88-3	9/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/18/96	U	0.5	ug/L
FID Surrogate Recovery:		91%		70%-130%	(Lin
PID Surrogate Recovery:		97%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-5(D)	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3213-10	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Matrix	: WATER
Date Received	: 9/13/96	Lab File Number(s)	: TVBX0916073
Date Prepared	: 9/17/96	Method Blank	: MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/18/96	U	0.1	mg/L
Benzene	71-43-2	9/18/96	U	0.4	ug/L
Toluene	108-88-3	9/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/18/96	0.8	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	1.2	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/18/96	1.6	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/18/96	2.9	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/18/96	1.4	0.5	ug/L
FID Surrogate Recovery:		88%		70%-130%	(Limits)
PID Surrogate Recovery:		95%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

P. McCall
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	ECS-27	Client Project Number	:	729691.28010
Lab Sample Number	:	96-3213-11	Lab Work Order	:	96-3213
Date Sampled	:	9/12/96	Matrix	:	WATER
Date Received	:	9/13/96	Lab File Number(s)	:	TVBX0916074
Date Prepared	:	9/17/96	Method Blank	:	MB091796
FID Dilution Factor	:	1.0			
PID Dilution Factor	:	1.0			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/18/96	U	0.1	mg/L
Benzene	71-43-2	9/18/96	U	0.4	ug/L
Toluene	108-88-3	9/18/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/18/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/18/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/18/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/18/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/18/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/18/96	U	0.5	ug/L
FID Surrogate Recovery:		90%		70%-130%	(Lim
PID Surrogate Recovery:		97%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

A McClell
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: ECS-26	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3213-12	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Matrix	: WATER
Date Received	: 9/13/96	Lab File Number(s)	: TVBX0916078
Date Prepared	: 9/17/96	Method Blank	: MB091796
FID Dilution Factor	: 100		
PID Dilution Factor	: 100		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/18/96	21	10	mg/L
Benzene	71-43-2	9/18/96	U	40	ug/L
Toluene	108-88-3	9/18/96	1000	40	ug/L
Chlorobenzene	108-90-7	9/18/96	U	40	ug/L
Ethyl Benzene	100-41-4	9/18/96	720	40	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	4500	40	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/18/96	210	40	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/18/96	490	40	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/18/96	290	40	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/18/96	160	50	ug/L
FID Surrogate Recovery:		90%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-130%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

P. McClell
Approved

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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: ECS-29	Client Project No.	: 729691.28010
Lab Sample No.	: 96-3213-02	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 9/13/96	Matrix	: WATER
Date Prepared	: 9/17/96	Lab File Number(s)	: TVBX0916063,64
Date Analyzed	: 9/18/96	Method Blank	: MB091796
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#) Limits %REC
Gasoline	2.00	0.00	1.93	96.4%	55 - 128
Surrogate **	---	---	---	91%	70 - 128

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#) Limits	
					RPD	%REC
Gasoline	2.00	1.95	97.6%	1.2	40.5	58 - 128
Surrogate **	---	---	90%	NA	NA	70 - 128

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:
NA = Not analyzed/not applicable.
* = Values outside of QC limits.
** = 1,2,4-Trichlorobenzene
# = Limits established 8/12/96, MAB

Comments:

K. Hollman
Analyst

P. McClella
Approved

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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MP-1	Client Project No.	: 729691.28010
Lab Sample No.	: 96-3213-03	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 9/13/96	Matrix	: WATER
Date Prepared	: 9/17/96	Lab File Number(s)	: TVBX0916065,66
Date Analyzed	: 9/18/96	Method Blank	: MB091796
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#) Limits %REC
Gasoline	2.00	0.00	1.97	98.3%	55 - 128
Surrogate **	---	---	---	92%	70 - 128

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#) Limits	
					RPD	%REC
Gasoline	2.00	1.95	97.3%	1.0	40.5	58 - 128
Surrogate **	---	---	91%	NA	NA	70 - 128

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:
NA = Not analyzed/not applicable.
* = Values outside of QC limits.
** = 1,2,4-Trichlorobenzene
# = Limits established 8/12/96, MAB

Comments: ______________________

K. Hollman
Analyst

P. McCall
Approved

MS3213B.XLS; 9/20/96

Evergreen Analytical, Inc.
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EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MP-3	Client Project No.	: 729691.28010
Lab Sample No.	: 96-3213-07	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	EPA Method No.	: 602/8020
Date Received	: 9/13/96	Matrix	: WATER
Date Prepared	: 9/18/96	Lab File Number(s)	: TVBX0916082,83
Date Analyzed	: 9/18/96	Method Blank	: MB091896
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L) MS	Concentration (ug/L) MSD	Comments
Benzene	20.0	0.0	18.7	18.8	
Toluene	20.0	0.0	18.5	18.4	
Chlorobenzene	20.0	0.0	18.5	18.6	
Ethylbenzene	20.0	0.0	18.7	18.7	
m,p-Xylene	20.0	0.0	19.7	19.6	
o-Xylene	20.0	0.0	19.2	19.2	
1,3,5-TMB	20.0	0.0	18.9	19.0	
1,2,4-TMB	20.0	0.0	19.0	19.0	
1,2,3-TMB	20.0	0.0	19.0	19.0	
1,2,3,4-TeMB	20.0	0.0	20.3	18.8	
Surrogate	100.0	97%	93%	96%	% RECOVERY

Compound		MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits RPD	QC# Limits %REC
Benzene		93.5	94.0	0.5	19	59 - 127
Toluene		92.5	92.0	0.5	20	59 - 127
Chlorobenzene		92.5	93.0	0.5	17	67 - 128
Ethylbenzene		93.5	93.5	0.0	20	57 - 125
m,p-Xylene		98.5	98.0	0.5	19	58 - 130
o-Xylene		96.0	96.0	0.0	20	59 - 128
1,3,5-TMB		94.5	95.0	0.5	21	69 - 113
1,2,4-TMB		95.0	95.0	0.0	27	70 - 115
1,2,3-TMB		95.0	95.0	0.0	18	72 - 114
1,2,3,4-TeMB		101.5	94.0	7.7	32	64 - 127
Surrogate		93.0	96.0	NA	NA	70 - 128

#= Limits established 8/12/96, MAB
*= Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments:

K. Holloman
Analyst

P. McClelle
Approved

EVERGREEN ANALYTICAL, INC.
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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: LCS091796-GAS	Matrix	: WATER
Date Prepared	: 9/17/96	Method Numbers	: EPA 5030/8015 Modified
Date Analyzed	: 9/17/96	Instrument Name	: TVHBTEX2
Lab File Number(s)	: TVBX0916053		

Compound Name	Theoretical Concentration (mg/L)	LCS Concentration (mg/L)	LCS % Recovery	QC Limit % Recovery
Gasoline	2.00	1.95	97.7	81 - 130
Surrogate Recovery:		95%		70 - 128

QUALIFIERS

B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA = Not Available/Not Applicable.
** = Limits established 8/12/96 for TVHBTEX2. MAB

M. Blecha
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
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EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number	:	LCS091796-BTEX	Dilution Factor	:	1.00
Date Extracted/Prepared	:	9/17/96	Method	:	602/8020
Date Analyzed	:	9/17/96	Matrix	:	Water
Spike Amount (ug/L)	:	20.0	Lab File No.	:	TVBX0916054

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	18.8	94.0	74 - 117
Toluene	108-88-3	18.9	94.5	75 - 120
Chlorobenzene	108-90-7	16.5	82.5	75 - 117
Ethyl Benzene	100-41-4	17.7	88.5	80 - 122
m,p-Xylene	108-38-3 106-42-3	37.7	94.3	76 - 122
o-Xylene	95-47-6	18.5	92.5	76 - 12[illegible]
MTBE	1634-04-4	21.0	105.0	71 - 134
1,3,5-Trimethylbenzene	108-67-8	16.1	80.5	64 - 123
1,2,4-Trimethylbenzene	95-63-6	17.3	86.5	75 - 114
1,2,3-Trimethylbenzene	526-73-8	20.0	100.0	81 - 130
1,2,3,4-Tetramethylbenzene	488-23-3	18.2	91.0	71 - 134
Surrogate Recovery:		98%		70 - 128

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:
E = Extrapolated value. Value exceeds that of the calibration range.
U = Compound analyzed for, but not detected.
B = Compound found in blank and sample. Compare blank and sample data.
NA = Not available/Not analyzed.
** = Limits established 8/12/96 for TVHBTEX2. MAB

M. Blecha
Analyst

K. Hollman
Approved

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Method 8010 Chlorinated VOC's Method Blank Report

Method Blank	: RB092696	Client Project No.	: 729691.28010 Westover ARB
Date Prepared	: 09/26/96	Lab Project No.	: 96-3213
Date Analyzed	: 09/26/96	Lab File No.	: HALL0926\021F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 92% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES: ____________________

Analyst

Approved

HLW3213.XLS; 10/3/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: MP-5(D)	Client Project No.	: 729691.28010 Westover ARB
Lab Sample No.	: 96-3213-10	Lab Project No.	: 96-3213
Date Sampled	: 09/12/96	Matrix	: Water
Date Received	: 09/13/96	Lab File No.	: HALL0926\024F0101
Date Prepared	: 09/26/96	Method Blank	: RB092696
Date Analyzed	: 09/26/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	0.42 J X	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	[illegible]
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 93% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES: X = Present in reagent blank at 0.37 ppb.

Analyst

Approved

HLW3213.XLS; 10/3/96

Evergreen Analytical, Inc.
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(303) 425-6021

EPA 601/8010 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MP-5(D)	Client Project No.	: 729691.28010 Westover ARB
Lab Sample No.	: 96-3213-10	Lab Project No.	: 96-3213
Date Sampled	: 09/12/96	EPA Method No.	: 8010
Date Received	: 09/13/96	Matrix	: Water
Date Prepared	: 09/26/96	Lab File Number(s)	: HALL\0926\029,30
Date Analyzed	: 09/26/96	Method Blank	: RB092696
		Dilution Factor	: 1

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L) MS	Concentration (ug/L) MSD	Comments
1,1-Dichloroethene	20.0	0.42	17.23	15.29	
Trichloroethene	20.0	0.00	15.80	14.86	
Chlorobenzene	20.0	0.00	12.89	13.01	
Surrogate	100.0	92.79	112.48	100.13	

Compound		MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits RPD	QC# Limits %REC		
1,1-Dichloroethene		84	74	12.2	25	50	-	150
Trichloroethene		79	74	6.1	25	50	-	150
Chlorobenzene		64	65	0.9	25	55	-	150
Surrogate		112%	100%	NA	NA	70	-	130

* = Values outside of QC limits.

RPD: 0 out of (3) outside limits.

Spike Recovery: 0 out of (6) outside limits.

Comments:

Analyst

Approved

Method 8010 Quality Control Samples

Date Performed: 9/26/96

Reference Standard: V832

Analyte	M	Method Blank	Sample	Sample Spike	Control Spike	Spike Amt	Spike Recoveries Sample	#	Spike Recoveries Control	#	QC Recovery Range %L - %H	QC Recovery Range Low - High
Vinyl Chloride	w			19.838	21.494	20.0	99%		107%		28 - 163	5.60 - 32.60
Chloroethane	*			19.846	19.374	20.0	99%		97%		46 - 137	9.20 - 27.40
1,1-Dichloroethene	*	0.366	0.420	20.853	20.010	20.0	102%		98%		28 - 167	5.60 - 33.40
Dichloromethane	*			17.499	20.255	20.0	87%		101%		25 - 162	5.00 - 32.40
trans-1,2-Dichloroethene	*			19.883	19.981	20.0	99%		100%		38 - 155	7.60 - 31.00
1,1-Dichloroethane	*			20.106	19.430	20.0	101%		97%		47 - 132	9.40 - 26.40
cis-1,2-Dichloroethene	*			20.648	20.251	20.0	103%		101%		-	-
1,1,1-Trichloroethane	*			19.668	19.716	20.0	98%		99%		41 - 138	8.20 - 27.60
Carbon Tetrachloride	*			19.757	19.388	20.0	99%		97%		43 - 143	8.60 - 28.60
Trichloroethene	w			21.308	22.082	20.0	107%		110%		35 - 146	7.00 - 29.20
1,1,2-Trichloroethane	w			21.074	20.625	20.0	105%		103%		39 - 136	7.80 - 27.20
Tetrachloroethene	*			19.954	19.767	20.0	100%		99%		26 - 162	5.20 - 32.40
1,1,1,2-Tetrachloroethane	*			18.730	19.315	20.0	94%		97%		-	-
Chlorobenzene	*			20.272	19.588	20.0	101%		98%		1 - 150	0.16 - 30.00
1,1,2,2-Tetrachloroethane	*			25.485	22.863	20.0	127%		114%		8 - 184	1.60 - 36.80
2-Chlorotoluene	*			18.996	19.412	20.0	95%		97%		-	-
4-Chlorotoluene	*			19.124	20.050	20.0	96%		100%		-	-
1,3-Dichlorobenzene	*			19.426	20.017	20.0	97%		100%		7 - 187	1.40 - 37.40
1,2-Dichlorobenzene	*	0.045		16.846	16.996	20.0	84%		85%		0 - 208	0.00 - 41.60

M = Applicable matrices. (* = Soil and Water. w = Water only.)

= Marks a spike recovery out of limits.
If recovery is outside method limit, marked with "*".
If recovery is outside a guideline, marked with "~".
If the sample spike recovery is outside the limit and the control spike is outside the limit also, the control is marked with "**" or "~~".

Notes on recovery limits:

All spiked analytes must be detected even if low limit is 0.
For analytes not listed in the method, recovery limits of 50-150% will be used as guidelines until limits can be established.

Corrective Actions:

Unacceptable sample spike recovery requires acceptable control spike recovery. If both recoveries are outside limits, corrective action must be taken. One recovery outside limits and the other acceptable, is a warning. Repeated failure requires corrective action. Re ies outside guidelines should be compared to historical data av e to determine if corrective action is required.

EVERGREEN ANALYTICAL, INC.
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Methane Report Form
Method Blank Report

Method Blank Number	: GB092396	Client Project No.	: 729691.28010
Date Extracted/Prepared	: 9/23/96	Lab Work Order	: 96-3213
Date Analyzed	: 9/23/96	Dilution Factor	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS0923002

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3213.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form

Client Sample Number	: CEA-5	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-01	Lab Work Order	: 96-3213
Date Sampled	: 9/11/96	Dilution Factor	: 1.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923010

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.017	0.002

Temperature	:	72.1 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	96.179 ug
Atomic weight(Methane)	:	16 g

Saturation Concentration	Meth	0.004[illegible]9
Concentration in Head Space	Meth	0.01302895

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3213.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: ECS-29	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-02	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 1.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923011

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.010	0.002

Temperature	: 72.1 F	Saturation Concentration	Meth	0.002414887
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.007607345
Head space created	: 4 ml			
Methane Area	: 56.157 ug			
Atomic weight(Methane)	: 16 g			

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Bill Michener
Analyst

K Holloman
Approved

AF3213.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MP-1	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-03	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 1.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923012

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.009	0.002

Temperature	:	73.2 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	50.993 ug

Saturation Concentration	Meth	0.0021[illegible]2
Concentration in Head Space	Meth	0.00689353

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3213.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MP-7	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-05	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 1.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923013

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	:	72.6 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	0 ug
Atomic weight(Methane)	:	16 g

Saturation Concentration	Meth	0
Concentration in Head Space	Meth	0

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3213.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MP-8	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-06	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 50.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923016

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	1.9	0.1

Temperature	:	72.3 F
Amount Injected	:	0.01 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	213.775 ug
Atomic weight(Methane)	:	16 g

Saturation Concentration	Meth	0.4596[illegible]3
Concentration in Head Space	Meth	1.44741395

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Analyst

K. Hollman
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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MP-3	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-07	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 1.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923017

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	:	72.4 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	0 ug

Saturation Concentration	Meth	0
Concentration in Head Space	Meth	0

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Analyst

K. Hollman
Approved

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MP-4	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-08	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 1.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923019

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 72.5 F	Saturation Concentration	Meth	
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	
Head space created	: 4 ml			
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MP-5(S)	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-09	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 1.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923020

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	:	72.5 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	0 ug

Saturation Concentration	Meth	0
Concentration in Head Space	Meth	0

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hellman
Approved

AF3213.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MP-5(S)	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-09Dup	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 1.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923021

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	:	72.7 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	0 ug

Saturation Concentration Meth ______

Concentration in Head Space Meth ______

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3213.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MP-5(D)	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-10	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 50.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923022

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	1.2	0.1

Temperature	: 72.8 F	Saturation Concentration Meth	0.27741722
Amount Injected	: 0.01 ml		
Total Volume of Sample	: 43 ml	Concentration in Head Space Meth	0.872766629
Head space created	: 4 ml		
Methane Area	: 129.024 ug		
Atomic weight(Methane)	: 16 g		

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Bill Michener
Analyst

K. Hollman
Approved

AF3213.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: ECS-27	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-11	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 1.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923023

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 72.6 F	Saturation Concentration	Meth	
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	
Head space created	: 4 ml			
Methane Area	: 0 ug			
Atomic weight(Methane)	: 16 g			

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Analyst

K. Hollman
Approved

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4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: ECS-26	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3213-12	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	Dilution Factor	: 1.00
Date Received	: 9/13/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923024

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 72.6 F	Saturation Concentration	Meth	0
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0
Head space created	: 4 ml			
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3213.XLS

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane Gas Matrix Spike / Matrix Spike Duplicate Report

Client Sample No.	: MP-7	Client Project No.	: 729691.28010
Lab Sample No.	: 96-3213-05	Lab Work Order	: 96-3213
Date Sampled	: 9/12/96	EPA Method No.	: RSKSOP-175M
Date Received	: 9/13/96	Matrix	: Water
Date Prepared	: 9/23/96	Method Blank	: GB092396
Date Analyzed	: 9/23/96	Lab File No's.	: GAS0923014,015
E.A. MS/MSD Spike Source No.	: 1886		

Compound	Spike Added (ug)	Sample Concentration (ug)	MS Concentration (ug)	MS %REC	QC Limits %REC
Methane Gas	500	0	381	76	40-89

Compound	Spike Added (ug)	MSD Concentration (ug)	MSD %REC	RPD	QC Limits RPD	QC Limits %REC
Methane Gas	500	377	75	0.9	0-24.4	40-89

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available

Note: The Spike was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Analyst

K. Holloman
Approved

MS3213.XLS; 9/25/96

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane LCS Report Form

LCS No.	: LCS092396	EPA Method No.	: RSKSOP-175M
Date Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Method Blank	: GB092396
E.A. LCS Source No.	: 1886	Lab File No.	: GAS0923009

Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	418	84	67-85

Spike Recovery: 0 out of (1) outside limits.

Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available.

Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

				Westover ARB
Date Sampled	: 9/11,12/96	Client Project ID.	:	729691.28010
Date Received	: 9/13/96	Lab Project Number	:	96-3213
Date Prepared	: 9/13/96	Method	:	EPA 300.0
Date Analyzed	: 9/13/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride (mg/L)	Dilution Factor
96-3213-01	CEA-5	Water	18.4	1
96-3213-02	ECS-29	Water	3.0	1
96-3213-02 Duplicate	ECS-29 Duplicate	Water	3.2	1
96-3213-03	MP-1	Water	3.6	1
96-3213-05	MP-7	Water	2.8	1
96-3213-06	MP-8	Water	7.0	1
Method Blank	(9/12/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3213-02	ECS-29 Matrix Spike	10.0	3.0	12.0	90
96-3213-02	ECS-29 Matrix Spike Dup	10.0	3.0	11.8	87
MS/MSD RPD					3.0

Jeff Hole
Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

					Westover ARB
Date Sampled	: 9/11,12/96	Client Project ID.	:	729691.28010
Date Received	: 9/13/96	Lab Project Number	:	96-3213
Date Prepared	: 9/13/96	Method	:	EPA 300.0
Date Analyzed	: 9/13/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride (mg/L)	Dilution Factor
96-3213-07	MP-3	Water	3.1	1
96-3213-08	MP-4	Water	3.4	1
96-3213-09	MP-5 (S)	Water	3.8	1
96-3213-10	MP-5 (D)	Water	3.9	1
96-3213-11	ECS-27	Water	4.2	1
96-3213-12	ECS-26	Water	7.5	1

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	:	9/11,12/96	Client Project ID.	:	Westover ARB 729691.28010
Date Received	:	9/13/96	Lab Project Number	:	96-3213
Date Prepared	:	9/13/96	Method	:	EPA 300.0
Date Analyzed	:	9/13/96	Detection Limit	:	0.076 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N (mg/L)	Dilution Factor
96-3213-01	CEA-5	Water	<0.076	1
96-3213-02	ECS-29	Water	<0.076	1
96-3213-02 Duplicate	ECS-29 Duplicate	Water	<0.076	1
96-3213-03	MP-1	Water	<0.076	1
96-3213-05	MP-7	Water	<0.076	1
96-3213-06	MP-8	Water	<0.076	1
Method Blank	(9/12/96)		<0.076	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3213-02	ECS-29 Matrix Spike	10.0	<0.25	10.1	101
96-3213-02	ECS-29 Matrix Spike Dup	10.0	<0.25	9.6	96
MS/MSD RPD					5.2

* = Quality assurance results reported as Nitrite (NO_2).

Analyst

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(303) 425-6021

Anion Report

				Westover ARB
Date Sampled	: 9/11,12/96	Client Project ID.	:	729691.28010
Date Received	: 9/13/96	Lab Project Number	:	96-3213
Date Prepared	: 9/13/96	Method	:	EPA 300.0
Date Analyzed	: 9/13/96	Detection Limit	:	0.076 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N (mg/L)	Dilution Factor
96-3213-07	MP-3	Water	<0.076	1
96-3213-08	MP-4	Water	<0.076	1
96-3213-09	MP-5 (S)	Water	<0.076	1
96-3213-10	MP-5 (D)	Water	<0.076	1
96-3213-11	ECS-27	Water	<0.076	1
96-3213-12	ECS-26	Water	<0.076	1

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

					Westover ARB
Date Sampled	: 9/11,12/96		Client Project ID.	:	729691.28010
Date Received	: 9/13/96		Lab Project Number	:	96-3213
Date Prepared	: 9/13/96		Method	:	EPA 300.0
Date Analyzed	: 9/13/96		Detection Limit	:	0.056 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrate-N (mg/L)	Dilution Factor
96-3213-01	CEA-5	Water	1.1	1
96-3213-02	ECS-29	Water	2.8	1
96-3213-02 Duplicate	ECS-29 Duplicate	Water	2.8	1
96-3213-03	MP-1	Water	0.41	1
96-3213-05	MP-7	Water	0.33	1
96-3213-06	MP-8	Water	<0.056	1
Method Blank	(9/12/96)		<0.056	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3213-02	ECS-29 Matrix Spike	10.0	12.4	22.7	104
96-3213-02	ECS-29 Matrix Spike Dup	10.0	12.4	22.5	102
MS/MSD RPD					1.9

* = Quality assurance results reported as Nitrate (NO_3).

Analyst

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EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

					Westover ARB
Date Sampled	: 9/11,12/96		Client Project ID.	:	729691.28010
Date Received	: 9/13/96		Lab Project Number	:	96-3213
Date Prepared	: 9/13/96		Method	:	EPA 300.0
Date Analyzed	: 9/13/96		Detection Limit	:	0.056 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrate-N (mg/L)	Dilution Factor
96-3213-07	MP-3	Water	0.29	1
96-3213-08	MP-4	Water	1.4	1
96-3213-09	MP-5 (S)	Water	2.4	1
96-3213-10	MP-5 (D)	Water	<0.056	1
96-3213-11	ECS-27	Water	1.2	1
96-3213-12	ECS-26	Water	0.57	1

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.

4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/11,12/96		Client Project ID.	:	Westover ARB 729691.28010
Date Received	: 9/13/96		Lab Project Number	:	96-3213
Date Prepared	: 9/13/96		Method	:	EPA 300.0
Date Analyzed	: 9/13/96		Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Sulfate (mg/L)	Dilution Factor
96-3213-01	CEA-5	Water	5.4	1
96-3213-02	ECS-29	Water	17.0	1
96-3213-02 Duplicate	ECS-29 Duplicate	Water	17.1	1
96-3213-03	MP-1	Water	9.2	1
96-3213-05	MP-7	Water	15.1	1
96-3213-06	MP-8	Water	5.7	1
Method Blank	(9/12/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3213-02	ECS-29 Matrix Spike	10.0	17.0	27.2	102
96-3213-02	ECS-29 Matrix Spike Dup	10.0	17.0	27.2	102
MS/MSD RPD					0

Jeff Hol
Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/11,12/96		Client Project ID.	:	Westover ARB 729691.28010
Date Received	: 9/13/96		Lab Project Number	:	96-3213
Date Prepared	: 9/13/96		Method	:	EPA 300.0
Date Analyzed	: 9/13/96		Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Sulfate (mg/L)	Dilution Factor
96-3213-07	MP-3	Water	4.5	1
96-3213-08	MP-4	Water	5.9	1
96-3213-09	MP-5 (S)	Water	8.9	1
96-3213-10	MP-5 (D)	Water	8.3	1
96-3213-11	ECS-27	Water	10.9	1
96-3213-12	ECS-26	Water	11.3	1

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Analysis Report

Date Sampled	: 9/12/96	Client Project ID.	: 729691.28010
Date Received	: 9/13/96	Lab Project Number	: 96-3213
Date Prepared	: 9/16/96	Method	: EPA 310.1
Date Analyzed	: 9/16/96	Detection Limit	: 5.0 mg $CaCO_3$/L

Evergreen Sample #	Client Sample ID.	Matrix	Total Alkalinity (mg $CaCO_3$/L)	Dilution Factor
96-3213-02	ECS-29	Water	32.8	1
96-3213-11	ECS-27	Water	13.3	1
96-3213-12	ECS-26	Water	97.5	1
96-3213-12 Duplicate	ECS-26	Water	94.7	1
Method Blank			<5.0	

Quality Assurance

Reference	True Value (mg$CaCO_3$/L)	Result (mg$CaCO_3$/L)	% Recovery
ERA Minerals Lot #9970	180	179	99

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Total Organic Carbon

Date Sampled	: 9/12/96	Client Project ID.	: Westover ARB 729691.28010
Date Received	: 9/13/96	Lab Project Number	: 96-3213
Date Prepared	: 9/19/96	Method	: EPA 415.1
Date Analyzed	: 9/19/96	Detection Limit	: 1.0 mg C/L

Evergreen Sample #	Client Sample ID.	Matrix	TOC mg C/L	Dilution Factor
96-3213-11	ECS-27	Water	1.7	1
96-3213-11 Dup	ECS-27 Dup	Water	1.6	1
Method Blank	(9/19/96)		<1.0	

Quality Assurance

		Spike Amount (mgC/L)	Sample Result (mgC/L)	Spike Result (mgC/L)	% Recovery
96-3151-01	MW-38 Matrix Spike	10.0	1.7	13.7	120
96-3151-01	MW-38 Matrix Spike Dup	10.0	1.7	12.6	109
MS/MSD RPD					9.6

Analyst

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4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	:	MB091696	Client Project Number	:	729691.28010
Date Prepared	:	9/16/96	Lab Work Order	:	96-3235
Dilution Factor	:	1.0	Matrix	:	WATER
			Lab File Number	:	TVBX0916004

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	U	0.1	mg/L
Benzene	71-43-2	9/16/96	U	0.4	ug/L
Toluene	108-88-3	9/16/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/16/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/16/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/16/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/16/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/16/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/16/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/16/96	U	0.5	ug/L
FID Surrogate Recovery:		91%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
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Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB091796	Client Project Number	: 729691.28010
Date Prepared	: 9/17/96	Lab Work Order	: 96-3235
Dilution Factor	: 1.0	Matrix	: WATER
		Lab File Number	: TVBX0916041

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	U	0.1	mg/L
Benzene	71-43-2	9/17/96	U	0.4	ug/L
Toluene	108-88-3	9/17/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	U	0.5	ug/L
FID Surrogate Recovery:		93%		70%-130%	(Limits)
PID Surrogate Recovery:		97%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB2092396	Client Project Number	: 729691.28010
Date Prepared	: 9/23/96	Lab Work Order	: 96-3235
Dilution Factor	: 1.0	Matrix	: WATER
		Lab File Number	: TVBX0923003

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/23/96	U	0.1	mg/L
Benzene	71-43-2	9/23/96	U	0.4	ug/L
Toluene	108-88-3	9/23/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/23/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/23/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/23/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/23/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/23/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/23/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/23/96	U	0.5	ug/L
FID Surrogate Recovery:		94%		70%-130%	(Limits)
PID Surrogate Recovery:		94%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	CEA-4	Client Project Number	:	729691.28010
Lab Sample Number	:	96-3235-01	Lab Work Order	:	96-3235
Date Sampled	:	9/12/96	Matrix	:	WATER
Date Received	:	9/14/96	Lab File Number(s)	:	TVBX0916057
Date Prepared	:	9/17/96	Method Blank	:	MB091796
FID Dilution Factor	:	5.0			
PID Dilution Factor	:	5.0			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	2.7	0.5	mg/L
Benzene	71-43-2	9/17/96	U	2.0	ug/L
Toluene	108-88-3	9/17/96	23	2.0	ug/L
Chlorobenzene	108-90-7	9/17/96	U	2.0	ug/L
Ethyl Benzene	100-41-4	9/17/96	160	2.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	530	2.0	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	3.6	2.0	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	18	2.0	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	4.5	2.0	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	14	2.5	ug/L
FID Surrogate Recovery:		92%		70%-130%	(Limits)
PID Surrogate Recovery:		98%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: TRIP BLANK	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-02	Lab Work Order	: 96-3235
Date Sampled	: N/A	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVBX0916018
Date Prepared	: 9/16/96	Method Blank	: MB091696
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	U	0.1	mg/L
Benzene	71-43-2	9/16/96	U	0.4	ug/L
Toluene	108-88-3	9/16/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/16/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/16/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/16/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/16/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/16/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/16/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/16/96	U	0.5	ug/L
FID Surrogate Recovery:		91%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-8	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-03	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVB20923010
Date Prepared	: 9/23/96	Method Blank	: MB2092396
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/23/96	U	0.1	mg/L
Benzene	71-43-2	9/23/96	U	0.4	ug/L
Toluene	108-88-3	9/23/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/23/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/23/96	0.5	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/23/96	1.1	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/23/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/23/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/23/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/23/96	U	0.5	ug/L
FID Surrogate Recovery:		92%		70%-130%	(Limits)
PID Surrogate Recovery:		99%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-112	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-04	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVBX0916013
Date Prepared	: 9/16/96	Method Blank	: MB091696
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/16/96	U	0.1	mg/L
Benzene	71-43-2	9/16/96	U	0.4	ug/L
Toluene	108-88-3	9/16/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/16/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/16/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/16/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/16/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/16/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/16/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/16/96	U	0.5	ug/L
FID Surrogate Recovery:		92%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

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RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-9	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-05	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVBX0916023
Date Prepared	: 9/16/96	Method Blank	: MB091696
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	0.5	0.1	mg/L
Benzene	71-43-2	9/17/96	U	0.4	ug/L
Toluene	108-88-3	9/17/96	1.8	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	0.7	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	0.8	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	2.1	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	2.1	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	3.2	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	11	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	12	0.5	ug/L
FID Surrogate Recovery:		95%		70%-130%	(Limits)
PID Surrogate Recovery:		98%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
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J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: ECS-23	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-06	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVBX0916024
Date Prepared	: 9/16/96	Method Blank	: MB091696
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	U	0.1	mg/L
Benzene	71-43-2	9/17/96	U	0.4	ug/L
Toluene	108-88-3	9/17/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	U	0.5	ug/L
FID Surrogate Recovery:		89%		70%-130%	(Limits)
PID Surrogate Recovery:		95%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: ECS-28	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-07	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVBX0916025
Date Prepared	: 9/16/96	Method Blank	: MB091696
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	U	0.1	mg/L
Benzene	71-43-2	9/17/96	U	0.4	ug/L
Toluene	108-88-3	9/17/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	U	0.5	ug/L
FID Surrogate Recovery:		92%		70%-130%	(Limits)
PID Surrogate Recovery:		97%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-17	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-08	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVBX0916034,59
Date Prepared	: 9/16,17/96	Method Blanks	: MB091696, MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0,20		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	4.2	0.1	mg/L
Benzene	71-43-2	9/17/96	4.7	0.4	ug/L
Toluene	108-88-3	9/17/96	20	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	150	8.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	930	8.0	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	35	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	68	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	14	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	3.0	0.5	ug/L
FID Surrogate Recovery:		88%		70%-130%	(Limits)
PID Surrogate Recovery:		94%,96%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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RL = Reporting Limit.
NA = Not Available/Not Applicable.
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FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-113	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-09	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVBX0916035,60
Date Prepared	: 9/16,17/96	Method Blanks	: MB091696, MB091796
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0,20		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	4.4	0.1	mg/L
Benzene	71-43-2	9/17/96	4.7	0.4	ug/L
Toluene	108-88-3	9/17/96	22	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/18/96	130	8.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/18/96	750	8.0	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	35	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	70	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	14	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	3.4	0.5	ug/L
FID Surrogate Recovery:		87%		70%-130%	(Limits)
PID Surrogate Recovery:		94%,97%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Bleake
Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: IW-3	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-10	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVBX0916036
Date Prepared	: 9/16/96	Method Blank	: MB091696
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	5.3	0.1	mg/L
Benzene	71-43-2	9/17/96	U	0.4	ug/L
Toluene	108-88-3	9/17/96	8.7	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	18	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	2.0	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	16	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	26	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	110	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	57	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	26	0.5	ug/L
FID Surrogate Recovery:		97%		70%-130%	(Limits)
PID Surrogate Recovery:		97%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-10	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-11	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVBX0916026
Date Prepared	: 9/16/96	Method Blank	: MB091696
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	U	0.1	mg/L
Benzene	71-43-2	9/17/96	U	0.4	ug/L
Toluene	108-88-3	9/17/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	U	0.5	ug/L
FID Surrogate Recovery:		88%		70%-130%	(Limits)
PID Surrogate Recovery:		95%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

M. Blecha
Analyst

K. Hollman
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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-2	Client Project Number	: 729691.28010
Lab Sample Number	: 96-3235-12	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Matrix	: WATER
Date Received	: 9/14/96	Lab File Number(s)	: TVBX0916027
Date Prepared	: 9/16/96	Method Blank	: MB091696
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/17/96	U	0.1	mg/L
Benzene	71-43-2	9/17/96	U	0.4	ug/L
Toluene	108-88-3	9/17/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/17/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/17/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/17/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/17/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/17/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/17/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/17/96	U	0.5	ug/L
FID Surrogate Recovery:		89%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MW-8	Client Project No.	: 729691.28010
Lab Sample No.	: 96-3235-03	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	EPA Method No.	: 602/8020
Date Received	: 9/14/96	Matrix	: WATER
Date Prepared	: 9/16/96	Lab File Number(s)	: TVBX0916019,20
Date Analyzed	: 9/16/96	Method Blank	: MB091696
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L)		Comments
			MS	MSD	
Benzene	20.0	0.0	18.7	17.4	
Toluene	20.0	0.0	18.0	16.5	
Chlorobenzene	20.0	0.0	18.1	15.3	
Ethylbenzene	20.0	0.5	18.4	15.4	
m,p-Xylene	20.0	1.1	19.2	16.0	
o-Xylene	20.0	0.0	18.4	15.9	
1,3,5-TMB	20.0	0.0	17.3	15.5	
1,2,4-TMB	20.0	0.0	18.3	16.1	
1,2,3-TMB	20.0	0.0	17.9	15.8	
1,2,3,4-TeMB	20.0	0.0	18.2	15.9	
Surrogate	100.0	99%	96%	96%	% RECOVERY

Compound		MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits		
					RPD	%REC	
Benzene		93.5	87.0	7.2	19	59 -	127
Toluene		90.0	82.5	8.7	20	59 -	127
Chlorobenzene		90.5	76.5	17	17	67 -	128
Ethylbenzene		89.5	74.5	18	20	57 -	125
m,p-Xylene		90.5	74.5	19	19	58 -	130
o-Xylene		92.0	79.5	15	20	59 -	128
1,3,5-TMB		86.5	77.5	11	21	69 -	113
1,2,4-TMB		91.5	80.5	13	27	70 -	115
1,2,3-TMB		89.5	79.0	12	18	72 -	114
1,2,3,4-TeMB		91.0	79.5	13	32	64 -	127
Surrogate		96.0	96.0	NA	NA	70 -	128

= Limits established 8/12/96, MAB
* = Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments:

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Analyst

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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MW-112	Client Project No.	: 729691.28010
Lab Sample No.	: 96-3235-04	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 9/14/96	Matrix	: WATER
Date Prepared	: 9/16/96	Lab File Number(s)	: TVBX0916021,22
Date Analyzed	: 9/16/96	Method Blank	: MB091696
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#) Limits %REC
Gasoline	2.00	0.00	1.94	97.2%	55 - 128
Surrogate **	---	---	---	89%	70 - 128

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#) Limits	
					RPD	%REC
Gasoline	2.00	2.01	100.6%	3.5	40.5	58 - 128
Surrogate **	---	---	93%	NA	NA	70 - 128

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:
NA = Not analyzed/not applicable.
* = Values outside of QC limits.
** = 1,2,4-Trichlorobenzene
# = Limits established 8/12/96, MAB

Comments:

M. Blecha
Analyst

K. Hoffman
Approved

EVERGREEN ANALYTICAL, INC.
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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: LCS091796-GAS	Matrix	: WATER
Date Prepared	: 9/17/96	Method Numbers	: EPA 5030/8015 Modified
Date Analyzed	: 9/17/96	Instrument Name	: TVHBTEX2
Lab File Number(s)	: TVBX0916053		

Compound Name	Theoretical Concentration (mg/L)	LCS Concentration (mg/L)	LCS % Recovery	QC Limit % Recovery
Gasoline	2.00	1.95	97.7	81 - 130
Surrogate Recovery:		95%		70 - 128

QUALIFIERS
B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA=Not Available/Not Applicable.
** = Limits established 8/12/96 for TVHBTEX2. MAB

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Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
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EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number	: LCS091796-BTEX	Dilution Factor	: 1.00
Date Extracted/Prepared	: 9/17/96	Method	: 602/8020
Date Analyzed	: 9/17/96	Matrix	: Water
Spike Amount (ug/L)	: 20.0	Lab File No.	: TVBX0916054

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	18.8	94.0	74 - 117
Toluene	108-88-3	18.9	94.5	75 - 120
Chlorobenzene	108-90-7	16.5	82.5	75 - 117
Ethyl Benzene	100-41-4	17.7	88.5	80 - 122
m,p-Xylene	108-38-3 106-42-3	37.7	94.3	76 - 122
o-Xylene	95-47-6	18.5	92.5	76 - 120
MTBE	1634-04-4	21.0	105.0	71 - 134
1,3,5-Trimethylbenzene	108-67-8	16.1	80.5	64 - 123
1,2,4-Trimethylbenzene	95-63-6	17.3	86.5	75 - 114
1,2,3-Trimethylbenzene	526-73-8	20.0	100.0	81 - 130
1,2,3,4-Tetramethylbenzene	488-23-3	18.2	91.0	71 - 134
Surrogate Recovery:		98%		70 - 128

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:
E = Extrapolated value. Value exceeds that of the calibration range.
U = Compound analyzed for, but not detected.
B = Compound found in blank and sample. Compare blank and sample data.
NA = Not available/Not analyzed.
** Limits established 8/12/96 for TVHBTEX2. MAB

M. Blecha
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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: LCS2092396-GAS	Matrix	: WATER
Date Prepared	: 9/23/96	Method Numbers	: EPA 5030/8015 Modified
Date Analyzed	: 9/23/96	Instrument Name	: TVHBTEX2
Lab File Number(s)	: TVB20923017		

Compound Name	Theoretical Concentration (mg/L)	LCS Concentration (mg/L)	LCS % Recovery	QC Limit % Recovery
Gasoline	2.00	1.78	88.8	81 - 130
Surrogate Recovery:		98%		70 - 128

QUALIFIERS

B.= TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA=Not Available/Not Applicable.
** = Limits established 8/12/96 for TVHBTEX2. MAB

M. Bleha
Analyst

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EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number	: LCS2092396-BTEX	Dilution Factor	: 1.00
Date Extracted/Prepared	: 9/23/96	Method	: 602/8020
Date Analyzed	: 9/23/96	Matrix	: Water
Spike Amount (ug/L)	: 20.0	Lab File No.	: TVB20923018

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	20.9	104.5	74 - 117
Toluene	108-88-3	19.9	99.5	75 - 120
Chlorobenzene	108-90-7	18.8	94.0	75 - 117
Ethyl Benzene	100-41-4	19.9	99.5	80 - 122
m,p-Xylene	108-38-3 106-42-3	37.8	94.5	76 - 122
[illegible]ene	95-47-6	19.7	98.5	76 - 120
MTBE	1634-04-4	22.2	111.0	71 - 134
1,3,5-Trimethylbenzene	108-67-8	17.8	89.0	64 - 123
1,2,4-Trimethylbenzene	95-63-6	19.0	95.0	75 - 114
1,2,3-Trimethylbenzene	526-73-8	22.9	114.5	81 - 130
1,2,3,4-Tetramethylbenzene	488-23-3	20.5	102.5	71 - 134
Surrogate Recovery:		99%		70 - 128

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:
E = Extrapolated value. Value exceeds that of the calibration range.
U = Compound analyzed for, but not detected.
B = Compound found in blank and sample. Compare blank and sample data.
NA = Not available/Not analyzed.
[illegible] Limits established 8/12/96 for TVHBTEX2. MAB

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Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
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Method 8010 Chlorinated VOC's Method Blank Report

Method Blank	:	RB092696	Client Project No.	:	729691.28010 Westover ARB
Date Prepared	:	09/26/96	Lab Project No.	:	96-3235
Date Analyzed	:	09/26/96	Lab File No.	:	HALL0926\021F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	[illegible]
1,3-Dichlorobenzene	541-73-1	U	[illegible]
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 92% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW3235.XLS; 10/3/96

EVERGREEN ANALYTICAL, INC.
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Method 601/8010 Chlorinated VOC's Method Blank Report

Method Blank	: RB092796	Client Project No.	: 729691.28010 Westover ARB
Date Prepared	: 09/27/96	Lab Project No.	: 96-3235
Date Analyzed	: 09/27/96	Lab File No.	: HALL0927\004F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
cis-1,2-Dichloroethene	156-59-4	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 105% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

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Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: MP-9	Client Project No.	:	729691.28010 Westover ARB
Lab Sample No.	: 96-3235-05	Lab Project No.	:	96-3235
Date Sampled	: 09/13/96	Matrix	:	Water
Date Received	: 09/14/96	Lab File No.	:	HALL0926\031F0101
Date Prepared	: 09/26/96	Method Blank	:	RB092696
Date Analyzed	: 09/27/96	Dilution Factor	:	1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	[illegible]
4-Chlorotoluene	106-49-8	U	[illegible]
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 97% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES: X = Present in reagent blank at 0.37 ppb.

Analyst

Approved

HLW3235.XLS; 10/3/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	:	MW-17	Client Project No.	:	729691.28010 Westover ARB
Lab Sample No.	:	96-3235-08	Lab Project No.	:	96-3235
Date Sampled	:	09/13/96	Matrix	:	Water
Date Received	:	09/14/96	Lab File No.	:	HALL0926\032F0101
Date Prepared	:	09/26/96	Method Blank	:	RB092696
Date Analyzed	:	09/27/96	Dilution Factor	:	1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 97% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

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4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: IW-3	Client Project No.	: 729691.28010 Westover ARB
Lab Sample No.	: 96-3235-10	Lab Project No.	: 96-3235
Date Sampled	: 09/13/96	Matrix	: Water
Date Received	: 09/14/96	Lab File No.	: HALL0926\033F0101
Date Prepared	: 09/26/96	Method Blank	: RB092696
Date Analyzed	: 09/27/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	1.4	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	0.51 J X	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	E	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	4.1	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	13	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	19	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	[illegible]
4-Chlorotoluene	106-49-8	U	[illegible]
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	15	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 120% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES: X = Detected in reagent blank at 0.37ppb.

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4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: IW-3	Client Project No.	: 729691.28010 Westover ARB
Lab Sample No.	: 96-3235-10	Lab Project No.	: 96-3235
Date Sampled	: 09/13/96	Matrix	: Water
Date Received	: 09/14/96	Lab File No.	: HALL0927\005F0101
Date Prepared	: 09/27/96	Method Blank	: RB092796
Date Analyzed	: 09/27/96	Dilution Factor	: 5.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
cis-1,2-Dichloroethene	156-59-4	390	2

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 123% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

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Method 8010 Quality Control Samples

Date Performed: 9/27/96

Reference Standard: V832

Analyte	M	Method Blank	Sample	Sample Spike	Control Spike	Spike Amt	Spike Recoveries Sample	#	Control	#	QC Recovery Range % L - % H	Low - High
Vinyl Chloride	w			25.237	23.659	20.0	126%		118%		28 - 163	5.60 - 32.60
Chloroethane	*			21.203	21.165	20.0	106%		106%		46 - 137	9.20 - 27.40
1,1-Dichloroethene	*			21.582	20.122	20.0	108%		101%		28 - 167	5.60 - 33.40
Dichloromethane	*		0.891	21.724	21.121	20.0	104%		106%		25 - 162	5.00 - 32.40
trans-1,2-Dichloroethene	*			19.512	17.989	20.0	98%		90%		38 - 155	7.60 - 31.00
1,1-Dichloroethane	*			22.107	21.452	20.0	111%		107%		47 - 132	9.40 - 26.40
cis-1,2-Dichloroethene	*		77.293	99.402	22.238	20.0	111%		111%		-	-
1,1,1-Trichloroethane	*			22.571	21.011	20.0	113%		105%		41 - 138	8.20 - 27.60
Carbon Tetrachloride	*			22.966	21.920	20.0	115%		110%		43 - 143	8.60 - 28.60
Trichloroethene	w		0.179	21.648	23.078	20.0	107%		115%		35 - 146	7.00 - 29.20
1,1,2-Trichloroethane	w			23.371	23.017	20.0	117%		115%		39 - 136	7.80 - 27.20
Tetrachloroethene	*		0.946	23.931	21.896	20.0	115%		109%		26 - 162	5.20 - 32.40
1,1,1,2-Tetrachloroethane	*			20.368	20.391	20.0	102%		102%		-	-
Chlorobenzene	*			25.572	22.118	20.0	128%		111%		1 - 150	0.16 - 30.00
1,1,2,2-Tetrachloroethane	*			25.731	28.354	20.0	129%		142%		8 - 184	1.60 - 36.80
2-Chlorotoluene	*			22.545	22.736	20.0	113%		114%		-	-
4-Chlorotoluene	*			21.242	21.199	20.0	106%		106%		-	-
1,3-Dichlorobenzene	*			20.935	21.016	20.0	105%		105%		7 - 187	1.40 - 37.40
1,2-Dichlorobenzene	*		3.779	19.212	19.810	20.0	77%		99%		0 - 208	0.00 - 41.60

M = Applicable matrices. (* = Soil and Water. w = Water only.)

= Marks a spike recovery out of limits.
If recovery is outside method limit, marked with "*".
If recovery is outside a guideline, marked with "~".
If the sample spike recovery is outside the limit and the control spike is outside the limit also, the control is marked with "**" or "~~".

Notes on recovery limits:

All spiked analytes must be detected even if low limit is 0.
For analytes not listed in the method, recovery limits of 50-150% will be used as guidelines until limits can be established.

Corrective Actions:

Unacceptable sample spike recovery requires acceptable control spike recovery. If both recoveries are outside limits, corrective action must be taken. One recovery outside limits and the other acceptable, is a warning. Repeated failure requires corrective action. Re[illegible]ries outside guidelines should be compared to historical data av[illegible]le to determine if corrective action is required.

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Methane Report Form
Method Blank Report

Method Blank Number	: GB092396	Client Project No.	: 729691.28010
Date Extracted/Prepared	: 9/23/96	Lab Work Order	: 96-3235
Date Analyzed	: 9/23/96	Dilution Factor	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS0923002

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

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(303) 425-6021

Methane Report Form
Method Blank Report

Method Blank Number	: GB092596	Client Project No.	: 729691.28010
Date Extracted/Prepared	: 9/25/96	Lab Work Order	: 96-3235
Date Analyzed	: 9/25/96	Dilution Factor	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS0923043

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: CEA-4	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-01	Lab Work Order	: 96-3235
Date Sampled	: 9/12/96	Dilution Factor	: 1.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923025

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.147	0.002

Temperature	: 74.1 F	Saturation Concentration	Meth	0.035438295
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.111218744
Head space created	: 4 ml			
Methane Area	: 824.1 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: MW-8	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-03	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 1.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923026

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.005	0.002

Temperature	: 74.1 F	Saturation Concentration	Meth	0.0012[illegible]
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.00407140
Head space created	: 4 ml			
Methane Area	: 30.168 ug			
Atomic weight(Methane)	: 16 g			

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: MW-112	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-04	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 1.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923027

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.006	0.002

Temperature	: 74.2 F	Saturation Concentration	Meth	0.001422477
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.004463433
Head space created	: 4 ml			
Methane Area	: 33.079 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: MP-9	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-05	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 10.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923028

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.23	0.02

Temperature	:	74.5 F
Amount Injected	:	0.05 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	129.117 ug

Saturation Concentration	Meth	0.0555[illegible]8
Concentration in Head Space	Meth	0.17412294

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

[illegible]
Analyst

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(303) 425-6021

Methane Report Form

Client Sample Number	: MP-9	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-05Dup	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 10.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923030

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.22	0.02

Temperature	: 74.5 F	Saturation	Meth	0.053686803
Amount Injected	: 0.05 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.168363214
Head space created	: 4 ml	in Head Space		
Methane Area	: 124.846 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: ECS-23	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-06	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 1.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923031

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 74.6 F	Saturation Concentration	Meth
Amount Injected	: 0.5 ml		
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth
Head space created	: 4 ml		
Methane Area	: 0 ug		
Atomic weight(Methane)	: 16 g		

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: ECS-28	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-07	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 50.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Lab File No.	: GAS0923032

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	2.2	0.1

mperature	: 74.5 F	Saturation Concentration	Meth	0.532333424
Amount Injected	: 0.01 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	1.6694115
Head space created	: 4 ml			
Methane Area	: 247.583 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: MW-17	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-08	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 50.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923036

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	4.6	0.1

Temperature	: 74.6 F	Saturation Concentration	Meth	1.1189[illegible]0
Amount Injected	: 0.01 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	3.50847640
Head space created	: 4 ml			
Methane Area	: 520.424 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: MW-113	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-09	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 50.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923037

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	4.2	0.1

mperature	: 74.5 F	Saturation Concentration	Meth	1.013375709
Amount Injected	: 0.01 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	3.177972654
Head space created	: 4 ml			
Methane Area	: 471.311 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: IW-3	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-10	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 50.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923038

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	8.5	0.1

Temperature	:	74.6 F
Amount Injected	:	0.01 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	957.106 ug

Saturation Concentration	Meth	2.057[illegible]7
Concentration in Head Space	Meth	6.452

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

[illegible]
Analyst

K. Hollman
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4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MP-10	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-11	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 1.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923039

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 74.7 F	Saturation Concentration	Meth	0.000313144
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.000981659
Head space created	: 4 ml			
Methane Area	: 7.282 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

[signature]
Analyst

K. Hollman
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4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MP-2	Client Project No.	: 729691.28010
Lab Sample Number	: 96-3235-12	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	Dilution Factor	: 1.00
Date Received	: 9/14/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923040

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.005	0.002

Temperature	: 74.6 F	Saturation Concentration	Meth	0.0011[illegible]4
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.00360903
Head space created	: 4 ml			
Methane Area	: 26.767 ug			
Atomic weight(Methane)	: 16 g			

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K Hollman
Approved

AF3235.XLS

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane Gas Matrix Spike / Matrix Spike Duplicate Report

Client Sample No.	: ECS-23	Client Project No.	: 729691.28010
Lab Sample No.	: 96-3235-06	Lab Work Order	: 96-3235
Date Sampled	: 9/13/96	EPA Method No.	: RSKSOP-175M
Date Received	: 9/14/96	Matrix	: Water
Date Prepared	: 9/25/96	Method Blank	: GB092596
Date Analyzed	: 9/25/96	Lab File No's.	: GAS0923041,042
E.A. MS/MSD Spike Source No.	: 1886		

Compound	Spike Added (ug)	Sample Concentration (ug)	MS Concentration (ug)	MS %REC	QC Limits %REC
Methane Gas	500	0	306	61	40-89

Compound	Spike Added (ug)	MSD Concentration (ug)	MSD %REC	RPD	QC Limits RPD	QC Limits %REC
Methane Gas	500	302	60	1.2	0-24.4	40-89

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available

Note: The Spike was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Analyst

K Hollman
Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane LCS Report Form

LCS No.	: LCS092396	EPA Method No.	: RSKSOP-175M
Date Prepared	: 9/23/96	Matrix	: Water
Date Analyzed	: 9/23/96	Method Blank	: GB092396
E.A. LCS Source No.	: 1886	Lab File No.	: GAS0923009

Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	418	84	67-85

Spike Recovery: 0 out of (1) outside limits.

Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available.

Analyst

K. Hollman
Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane LCS Report Form

LCS No.	: LCS092596	EPA Method No.	: RSKSOP-175M
Date Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Method Blank	: GB092596
E.A. LCS Source No.	: 1886	Lab File No.	: GAS0923035

Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	412	82	67-85

Spike Recovery: 0 out of (1) outside limits.

Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available.

Analyst

K Hollman
Approved

LCS0925.XLS; 9/25/96

EVERGREEN ANALYTICAL, Inc.

4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/12,13/96	Client Project ID.	:	Westover ARB 729691.28010
Date Received	: 9/14/96	Lab Project Number	:	96-3235
Date Prepared	: 9/14/96	Method	:	EPA 300.0
Date Analyzed	: 9/14/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride mg/L	Dilution Factor
96-3235-01	CEA-4	Water	25.1	1
96-3235-03	MW-8	Water	3.1	1
96-3235-03 Duplicate	MW-8 Duplicate	Water	3.0	1
96-3235-04	MW-112	Water	3.9	1
96-3235-05	MP-9	Water	4.9	1
96-3235-06	ECS-23	Water	5.7	1
Method Blank	(9/14/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3235-03	MW-8 Matrix Spike	10.0	3.1	12.9	99
96-3235-03	MW-8 Matrix Spike Dup	10.0	3.1	12.4	94
MS/MSD RPD					5.2

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

					Westover ARB
Date Sampled	:	9/13/96	Client Project ID.	:	729691.28010
Date Received	:	9/14/96	Lab Project Number	:	96-3235
Date Prepared	:	9/14/96	Method	:	EPA 300.0
Date Analyzed	:	9/14/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride mg/L	Dilution Factor
96-3235-07	ECS-28	Water	3.1	1
96-3235-08	MW-17	Water	5.1	1
96-3235-09	MW-113	Water	3.2	1
96-3235-10	IW-3	Water	6.0	10
96-3235-11	MP-10	Water	0.9	1
96-3235-12	MP-2	Water	4.4	1

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/12,13/96	Client Project ID.	: Westover ARB 729691.28010
Date Received	: 9/14/96	Lab Project Number	: 96-3235
Date Prepared	: 9/14/96	Method	: EPA 300.0
Date Analyzed	: 9/14/96	Detection Limit	: 0.076 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N mg/L	Dilution Factor
96-3235-01	CEA-4	Water	<0.076	1
96-3235-03	MW-8	Water	<0.076	1
96-3235-03 Duplicate	MW-8 Duplicate	Water	<0.076	1
96-3235-04	MW-112	Water	<0.076	1
96-3235-05	MP-9	Water	<0.076	1
96-3235-06	ECS-23	Water	<0.076	1
Method Blank	(9/14/96)		<0.076	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3235-03	MW-8 Matrix Spike	10.0	<0.25	9.8	98
96-3235-03	MW-8 Matrix Spike Dup	10.0	<0.25	9.7	97
MS/MSD RPD					1.0

* = Quality assurance results reported as Nitrite (NO_2).

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

					Westover ARB
Date Sampled	:	9/13/96	Client Project ID.	:	729691.28010
Date Received	:	9/14/96	Lab Project Number	:	96-3235
Date Prepared	:	9/14/96	Method	:	EPA 300.0
Date Analyzed	:	9/14/96	Detection Limit	:	0.076 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N mg/L	Dilution Factor
96-3235-07	ECS-28	Water	<0.076	1
96-3235-08	MW-17	Water	<0.076	1
96-3235-09	MW-113	Water	<0.076	1
96-3235-10	IW-3	Water	<0.76 **	10
96-3235-11	MP-10	Water	*	1
96-3235-12	MP-2	Water	<0.076	1

* = See Nitrate as N report.

** = Raised detection limit due to matrix interference.

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/12,13/96			Westover ARB
		Client Project ID.	:	729691.28010
Date Received	: 9/14/96	Lab Project Number	:	96-3235
Date Prepared	: 9/14/96	Method	:	EPA 300.0
Date Analyzed	: 9/14/96	Detection Limit	:	0.056 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrate-N mg/L	Dilution Factor
96-3235-01	CEA-4	Water	2.4	1
96-3235-03	MW-8	Water	1.3	1
96-3235-03 Duplicate	MW-8 Duplicate	Water	1.3	1
96-3235-04	MW-112	Water	1.3	1
96-3235-05	MP-9	Water	<0.056	1
96-3235-06	ECS-23	Water	0.18	1
Method Blank	(9/14/96)		<0.056	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3235-03	MW-8 Matrix Spike	10.0	5.7	15.8	101
96-3235-03	MW-8 Matrix Spike Dup	10.0	5.7	15.7	100
MS/MSD RPD					1.4

* = Quality assurance results reported as Nitrate (NO_3).

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/13/96			Westover ARB
		Client Project ID.	:	729691.28010
Date Received	: 9/14/96	Lab Project Number	:	96-3235
Date Prepared	: 9/14/96	Method	:	EPA 300.0
Date Analyzed	: 9/14/96	Detection Limit	:	0.056 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrate-N mg/L	Dilution Factor
96-3235-07	ECS-28	Water	0.16	1
96-3235-08	MW-17	Water	0.14	1
96-3235-09	MW-113	Water	0.12	1
96-3235-10	IW-3	Water	0.064	1
96-3235-11	MP-10	Water	7.0*	1
96-3235-12	MP-2	Water	3.5	1

* = Result equals NO_2 plus NO_3 as N, as sample was analyzed outside of holding time on 9/26/96

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

				Westover ARB
Date Sampled	: 9/12,13/96	Client Project ID.	:	729691.28010
Date Received	: 9/14/96	Lab Project Number	:	96-3235
Date Prepared	: 9/14/96	Method	:	EPA 300.0
Date Analyzed	: 9/14/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Sulfate mg/L	Dilution Factor
96-3235-01	CEA-4	Water	14.5	1
96-3235-03	MW-8	Water	12.5	1
96-3235-03 Duplicate	MW-8 Duplicate	Water	12.5	1
96-3235-04	MW-112	Water	12.2	1
96-3235-05	MP-9	Water	1.3	1
96-3235-06	ECS-23	Water	11.3	1
Method Blank	(9/14/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3235-03	MW-8 Matrix Spike	10.0	12.5	22.8	103
96-3235-03	MW-8 Matrix Spike Dup	10.0	12.5	22.6	100
MS/MSD RPD					2.3

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.

4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled : 9/13/96
Date Received : 9/14/96
Date Prepared : 9/14/96
Date Analyzed : 9/14/96

Client Project ID. : Westover ARB 729691.28010
Lab Project Number : 96-3235
Method : EPA 300.0
Detection Limit : 0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Sulfate mg/L	Dilution Factor
96-3235-07	ECS-28	Water	7.5	1
96-3235-08	MW-17	Water	2.6	1
96-3235-09	MW-113	Water	4.6	1
96-3235-10	IW-3	Water	0.8	1
96-3235-11	MP-10	Water	36.8	1
96-3235-12	MP-2	Water	5.6	1

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Analysis Report

Date Sampled	: 9/13/96	Client Project ID.	: 729691.28010
Date Received	: 9/14/96	Lab Project Number	: 96-3235
Date Prepared	: 9/16/96	Method	: EPA 310.1
Date Analyzed	: 9/16/96	Detection Limit	: 5.0 mg $CaCO_3$/L

Evergreen Sample #	Client Sample ID.	Matrix	Total Alkalinity (mg $CaCO_3$/L)	Dilution Factor
96-3235-06	ECS-23	Water	113	1
96-3235-06 Dup	ECS-23 Dup	Water	111	1
96-3235-10	IW-3	Water	757	1
96-3235-12	MP-2	Water	45.9	1
Method Blank	(9/16/96)		<5.0	

Quality Assurance

Reference	True Value (mg$CaCO_3$/L)	Result (mg$CaCO_3$/L)	% Recovery
ERA Minerals Lot # 9970	180	179	99

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Total Organic Carbon

729691.28010

Date Sampled	:	9/13/96	Client Project ID.	:	Westover ARB
Date Received	:	9/14/96	Lab Project Number	:	96-3235
Date Prepared	:	9/30/96	Method	:	EPA 415.1
Date Analyzed	:	9/30/96	Detection Limit	:	1.0 mg C/L

Evergreen Sample #	Client Sample ID.	Matrix	TOC mg C/L	Dilution Factor
96-3235-08	MW-17	Water	174	1
96-3235-08 Dup	MW-17 Dup	Water	175	1
96-3235-09	MW-113	Water	178	1
Method Blank	(9/30/96)		<1.0	

Quality Assurance

		Spike Amount (mgC/L)	Sample Result (mgC/L)	Spike Result (mgC/L)	% Recovery
96-3235-08	MW-17 Matrix Spike	10.0	174	183	90
96-3235-08	MW-17 Matrix Spike Dup	10.0	174	185	113
MS/MSD RPD					22.7

Analyst

Approved

SEP 2 4 1996

CUSTOMER #:
02604

HUFFMAN
LABORATORIES, INC.
Quality Analytical Services Since 1936
4630 Indiana Street • Golden, CO 80403
Phone: (303) 278-4455 • FAX: (303) 278-7012

DATE 9/23/96
LAB# 206796
P.O. 13380
RECD 09/19

ANALYSIS REPORT

PATTY MC CLELLEN
EVERGREEN ANALYTICAL, INC
4036 YOUNGFIELD STREET
WHEAT RIDGE CO 80033

SEQUENCE/ SAMPLE NUMBER	ANALYSIS CARBONATE C---%	TOTAL CARBON--%	ORGANIC C-----%	EAL Sample#	% moisture	Dry weight basis
01/MP-1-	<0.02	<0.05	<0.05	-3151-05	17.57	<0.
02/MP-3-	<0.02	<0.05	<0.05	-3185-04	3.24	<0.0
03/MP-4-	<0.02	<0.05	<0.05	-3185-05	17.30	<0.
04/SS-1-	<0.02	<0.05	<0.05	-3185-10	5.04	[illegible]
05/MP-6-	<0.02	<0.05	<0.05	-3185-12	5.15	<0.0
06/MP-2-	<0.02	0.50	0.50	-3185-13	10.24	0.5
07/MP-10-	<0.02	<0.05	<0.05	-3235-13	6.62	<0.0
08/MP-11-	<0.02	<0.05	<0.05	-3252-06	15.32	<0.0
09/MP-14-	<0.02	<0.05	<0.05	-3252-07	10.84	<0.0
10/SS-2-	<0.02	0.18	0.18	-3252-17	9.54	0.2
11/SS-3-	<0.02	<0.05	<0.05	3252-18	4.06	<0.0
12/SS-4-	<0.02	0.21	0.21	-3252-19	9.49	0.23
13/SS-5 (12')	<0.02	<0.05	<0.05	-3252-22	6.30	<0.0

Evergreen Analytical, Inc.

WORK ORDER Summary

25-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3237-02G	MW-2	Anions by IC Cl,NO2,NO3,SO4		Water	CL3	14-Sep-96	16-Sep-96	30-Sep-96	16-Sep-96
96-3237-03G	MW-16	Anions by IC Cl,NO2,NO3,SO4						30-Sep-96	16-Sep-96
96-3237-04G	MW-13	Anions by IC Cl,NO2,NO3,SO4						30-Sep-96	16-Sep-96
96-3237-05G	MW-14	Anions by IC Cl,NO2,NO3,SO4						30-Sep-96	16-Sep-96
96-3237-06G	MW-18	Anions by IC Cl,NO2,NO3,SO4						30-Sep-96	16-Sep-96
96-3237-07G	OBG-11	Anions by IC Cl,NO2,NO3,SO4						30-Sep-96	16-Sep-96
96-3237-08G	MW-19	Anions by IC Cl,NO2,NO3,SO4						30-Sep-96	16-Sep-96
96-3237-09G	ECS-20	Anions by IC Cl,NO2,NO3,SO4						30-Sep-96	16-Sep-96
96-3237-01A	Trip Blank	BTEX (Parsons List)			2			19-Sep-96	
96-3237-02A	MW-2	BTEX (Parsons List)				14-Sep-96		19-Sep-96	28-Sep-96
96-3237-03A	MW-16	BTEX (Parsons List)						19-Sep-96	28-Sep-96
96-3237-04A	MW-13	BTEX (Parsons List)						19-Sep-96	28-Sep-96
96-3237-05A	MW-14	BTEX (Parsons List)						19-Sep-96	28-Sep-96
96-3237-06A	MW-18	BTEX (Parsons List)						19-Sep-96	28-Sep-96
96-3237-07A	OBG-11	BTEX (Parsons List)						19-Sep-96	28-Sep-96
96-3237-07H	OBG-11MS	BTEX (Parsons List) Revision 9/25/96						19-Sep-96	28-Sep-96

# = Special list. See sample comments or test information.
HT = Holding Time expiration date.

Evergreen Analytical, Inc.

96-3237

WORK ORDER Summary

25-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3237-07I	OBG-11MSD	BTEX (Parsons List) Revision 9/25/96		Water	2	14-Sep-96	16-Sep-96	19-Sep-96	28-Sep-96
96-3237-08A	MW-19	BTEX (Parsons List)						19-Sep-96	28-Sep-96
96-3237-09A	ECS-20	BTEX (Parsons List)						19-Sep-96	28-Sep-96
96-3237-02D	MW-2	Methane						19-Sep-96	28-Sep-96
96-3237-03D	MW-16	Methane						19-Sep-96	28-Sep-96
96-3237-04D	MW-13	Methane						19-Sep-96	28-Sep-96
96-3237-05D	MW-14	Methane						19-Sep-96	28-Sep-96
96-3237-06D	MW-18	Methane						19-Sep-96	28-Sep-96
96-3237-07D	OBG-11	Methane						19-Sep-96	28-Sep-96
96-3237-08D	MW-19	Methane						19-Sep-96	28-Sep-96
96-3237-09D	ECS-20	Methane						19-Sep-96	28-Sep-96
96-3237-04H	MW-13	Purgeable Halocarbons 8010			9			30-Sep-96	28-Sep-96
96-3237-05H	MW-14	Total Alkalinity			CL3			30-Sep-96	28-Sep-96
96-3237-01A	Trip Blank	Total Volatile Hydrocarbons			2			19-Sep-96	
96-3237-02A	MW-2	Total Volatile Hydrocarbons				14-Sep-96		19-Sep-96	28-Sep-96
96-3237-03A	MW-16	Total Volatile Hydrocarbons						19-Sep-96	28-Sep-96
96-3237-04A	MW-13	Total Volatile Hydrocarbons						19-Sep-96	28-Sep-96
96-3237-05A	MW-14	Total Volatile Hydrocarbons						19-Sep-96	28-Sep-96
96-3237-06A	MW-18	Total Volatile Hydrocarbons						19-Sep-96	28-Sep-96
96-3237-07A	OBG-11	Total Volatile Hydrocarbons						19-Sep-96	28-Sep-96
96-3237-07H	OBG-11MS	Total Volatile Hydrocarbons Revision 9/25/96						19-Sep-96	28-Sep-96

# = S[illegible]l list. See sample comments or test information.
HT = [illegible]ding Time expiration date.

Evergreen Analytical, Inc.

96-3237

WORK ORDER Summary

25-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3237-07I	OBG-11MSD	Total Volatile Hydrocarbons Revision 9/25/96		Water	2	14-Sep-96	16-Sep-96	19-Sep-96	28-Sep-96
96-3237-08A	MW-19	Total Volatile Hydrocarbons						19-Sep-96	28-Sep-96
96-3237-09A	ECS-20	Total Volatile Hydrocarbons						19-Sep-96	28-Sep-96

# = Special list. See sample comments or test information.
HT = Holding Time expiration date.

CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

Page 1 of ____

Evergreen Analytical Inc.
4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

COMPANY Parsons ES
ADDRESS 1700 Broadway
CITY Denver STATE CO ZIP 80290
PHONE# 831-8100 FAX # 831-8208 FAX RESULTS Y / N

Sampler Name:
(signature) Saskia Hoff
(print) Saskia Hoffer

CLIENT CONTACT (print) Dave Moutoux
CLIENT PROJ. I.D. Westover ARB
EAL. QUOTE # ____ P.O.# ____
TURNAROUND REQUIRED* ☒ STD (2 wks) ☐ UST
☐ Other (Specify)* ____
*expedited turnaround subject to additional fee

Please **PRINT** all information:

EAL use only
Do not write in shaded area
W.O. # 96.3237
B.O.F. # NA
C/S (O) NA / NA
C/S (I) NA / Co
Cooler Temp. °C 12
Seals Intact Y / N / NA (Y circled)
Samples Pres. Y / N / NA (Y circled)
Headspace Y / N / NA (N circled)

CLIENT SAMPLE IDENTIFICATION	DATE SAMPLED	TIME	No. of Containers	Water-Drinking/Discharge/Ground (circle)	Soil / Solid / Air / Gas	Oil / Sludge / Multi-phase	TCLP VOA/BNA/Pest/Herb/Metals (circle)	VOA 8260/624/524.2 (circle)	BNA 8270/625 (circle)	Pesticides 8080/608 (circle)	Pest/PCBs 8080/608/508 (circle)	PCB Screen	Herbicides 8150/515 (circle)	BTEX 8020/602 (circle)/MTBE (circle) + TMB	TVPH 8015mod. (Gasoline)	TEPH 8015mod. (Diesel)	Total Metals-DW / NPDES / SW846 (circle & list metals below)	Dissolved Metals - DW / SW846 (circle & list metals below)	Oil & Grease 413.1	TRPH 418.1	Methane	Cl⁻, NO2, NO3, SO4	Alkalinity	8010 (VOCs)	TOC	~~MS/MSD~~ & 8H	Loc
Trip Blank	-	-	1	X										X	X						~~X~~						01 A
MW-2	9/14/96	0830	7	X										X	X						X	X					02 A-G
MW ~~AAP~~ -16	9/14/96	0845	7	X										X	X						X	X					03 A-G
MW-13	9/14/96	~~9:05~~ 9:15	9	X										X	X						X	X		X			04 A-I
MW-14	9/14/96	930	8	X										X	X						X	X	X				05 A-H
MW-18	9/14/96	10:15	7	X										X	X						X	X					06 A-G
~~EG~~ OBG-11	9/14/96	11:00	10	X										X	X						X	X				X	07 A-G
MW-19	9/14/96	11:30	7	X										X	X						X	X					08 A-G
ECS-20	9/14/96	11:40	7	X										X	X						X	X					09 A-G
OBG-11 MS/MSD	9/14/96	1100	3	X										X	X												*07 H-J
Sample Fraction														40V							40V	125 P	250 P	40V			Loc
Instructions:														2	2						2	a3	a3	11			Cont
														A-C							D-F	G	H	H-I		H-J	

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
[illegible]	9/14 1300	FEDEX	9/14 1300	FEDEX		[illegible]	091696

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB2091996	Client Project Number	: Westover ARB
Date Prepared	: 9/19/96	Lab Work Order	: 96-3237
Dilution Factor	: 1.0	Matrix	: WATER
		Lab File Number	: TVBX0919018

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/L
Benzene	71-43-2	9/20/96	U	0.4	ug/L
Toluene	108-88-3	9/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/L
FID Surrogate Recovery:		101%		70%-130%	(Limits)
PID Surrogate Recovery:		97%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Holloman
Analyst

P. McClellan
Approved

EVERGREEN ANALYTICAL, INC.
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Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB2092696	Client Project Number	: Westover ARB
Date Prepared	: 9/26/96	Lab Work Order	: 96-3237
Dilution Factor	: 1.0	Matrix	: WATER
		Lab File Number	: TVB20925033

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/26/96	U	0.1	mg/L
Benzene	71-43-2	9/26/96	U	0.4	ug/L
Toluene	108-88-3	9/26/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/26/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/26/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/26/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/26/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/26/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/26/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/26/96	U	0.5	ug/L
FID Surrogate Recovery:		98%		70%-130%	(Limits)
PID Surrogate Recovery:		98%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Analyst

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: Trip Blank	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3237-01	Lab Work Order	: 96-3237
Date Sampled	: NA	Matrix	: WATER
Date Received	: 9/16/96	Lab File Number(s)	: TVBX0919035
Date Prepared	: 9/20/96	Method Blank	: MB2091996
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/L
Benzene	71-43-2	9/20/96	U	0.4	ug/L
Toluene	108-88-3	9/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/L
FID Surrogate Recovery:		92%		70%-130%	(Limits)
PID Surrogate Recovery:		93%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K Hollman
Analyst

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-2	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3237-02	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Matrix	: WATER
Date Received	: 9/16/96	Lab File Number(s)	: TVBX0919022
Date Prepared	: 9/19/96	Method Blank	: MB2091996
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/L
Benzene	71-43-2	9/20/96	U	0.4	ug/L
Toluene	108-88-3	9/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	0.7	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/L
FID Surrogate Recovery:		98%		70%-130%	(Lim
PID Surrogate Recovery:		96%		70%-128%	(Lim

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-16	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3237-03	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Matrix	: WATER
Date Received	: 9/16/96	Lab File Number(s)	: TVBX0919023
Date Prepared	: 9/19/96	Method Blank	: MB2091996
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	0.1	0.1	mg/L
Benzene	71-43-2	9/20/96	3.0	0.4	ug/L
Toluene	108-88-3	9/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	1.6	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/L
FID Surrogate Recovery:		98%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-13	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3237-04	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Matrix	: WATER
Date Received	: 9/16/96	Lab File Number(s)	: TVBX0919024
Date Prepared	: 9/19/96	Method Blank	: MB2091996
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	0.5	0.1	mg/L
Benzene	71-43-2	9/20/96	1.5	0.4	ug/L
Toluene	108-88-3	9/20/96	3.8	0.4	ug/L
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/20/96	15	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	14	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	0.9	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	4.6	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	0.9	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/L
FID Surrogate Recovery:		96%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	MW-14	Client Project Number	:	Westover ARB
Lab Sample Number	:	96-3237-05	Lab Work Order	:	96-3237
Date Sampled	:	9/14/96	Matrix	:	WATER
Date Received	:	9/16/96	Lab File Number(s)	:	TVBX0919034
Date Prepared	:	9/20/96	Method Blank	:	MB2091996
FID Dilution Factor	:	10.0			
PID Dilution Factor	:	10.0			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	3	1.0	mg/L
Benzene	71-43-2	9/20/96	8.4	4.0	ug/L
Toluene	108-88-3	9/20/96	15	4.0	ug/L
Chlorobenzene	108-90-7	9/20/96	U	4.0	ug/L
Ethyl Benzene	100-41-4	9/20/96	84	4.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	230	4.0	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	4.0	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	25	4.0	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	10	4.0	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	5.0	ug/L
FID Surrogate Recovery:		95%		70%-130%	(Limits)
PID Surrogate Recovery:		93%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	MW-18	Client Project Number	:	Westover ARB
Lab Sample Number	:	96-3237-06	Lab Work Order	:	96-3237
Date Sampled	:	9/14/96	Matrix	:	WATER
Date Received	:	9/16/96	Lab File Number(s)	:	TVBX0919036,42
Date Prepared	:	9/20/96	Method Blank	:	MB2091996
FID Dilution Factor	:	5.0			
PID Dilution Factor	:	5.0; 100			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	11	0.5	mg/L
Benzene	71-43-2	9/20/96	200	2.0	ug/L
Toluene	108-88-3	9/20/96	1900	40	ug/L
Chlorobenzene	108-90-7	9/20/96	U	2.0	ug/L
Ethyl Benzene	100-41-4	9/20/96	170	2.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	740	2.0	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	22	2.0	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	57	2.0	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	11	2.0	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	2.5	ug/L
FID Surrogate Recovery:		95%		70%-130%	(Lir
PID Surrogate Recovery:		91%, 98%		70%-128%	(Lim

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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NA = Not Available/Not Applicable.
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FID = Flame ionization detector.
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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: OBG-11	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3237-07	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Matrix	: WATER
Date Received	: 9/16/96	Lab File Number(s)	: TVBX0919025
Date Prepared	: 9/19/96	Method Blank	: MB2091996
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/L
Benzene	71-43-2	9/20/96	0.5	0.4	ug/L
Toluene	108-88-3	9/20/96	11	0.4	ug/L
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/20/96	0.9	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	3.8	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/L
FID Surrogate Recovery:		98%		70%-130%	(Limits)
PID Surrogate Recovery:		96%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-19	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3237-08	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Matrix	: WATER
Date Received	: 9/16/96	Lab File Number(s)	: TVBX0919031,38
Date Prepared	: 9/19,20/96	Method Blank	: MB2091996
FID Dilution Factor	: 5.0		
PID Dilution Factor	: 1.0; 5.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	3.7	0.5	mg/L
Benzene	71-43-2	9/20/96	7.6	2.0	ug/L
Toluene	108-88-3	9/20/96	47	2.0	ug/L
Chlorobenzene	108-90-7	9/20/96	2.2	2.0	ug/L
Ethyl Benzene	100-41-4	9/20/96	90	2.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	380	2.0	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	4.8	2.0	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	19	2.0	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	8.0	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	1.2	0.5	ug/L
FID Surrogate Recovery:		93%		70%-130%	(Lim
PID Surrogate Recovery:		94%,93%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
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TVH = Total Volatile Hydrocarbons.

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: ECS-20	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3237-09	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Matrix	: WATER
Date Received	: 9/16/96	Lab File Number(s)	: TVBX0919030,39
Date Prepared	: 9/19,20/96	Method Blank	: MB2091996
FID Dilution Factor	: 20		
PID Dilution Factor	: 1.0; 20		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	12	2.0	mg/L
Benzene	71-43-2	9/20/96	35	0.4	ug/L
Toluene	108-88-3	9/20/96	1300	8.0	ug/L
Chlorobenzene	108-90-7	9/20/96	1.9	0.4	ug/L
Ethyl Benzene	100-41-4	9/20/96	710	8.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	2800	8.0	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	130	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	290	8.0	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	77	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	34	0.5	ug/L
FID Surrogate Recovery:		94%		70%-130%	(Limits)
PID Surrogate Recovery:		96%,94%		70%-128%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

AmClell
Approved

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MW-2	Client Project No.	: Westover ARB
Lab Sample No.	: 96-3237-02	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 9/16/96	Matrix	: WATER
Date Prepared	: 9/19/96	Lab File Number(s)	: TVBX0919019,20
Date Analyzed	: 9/20/96	Method Blank	: MB2091996
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#) Limits %REC
Gasoline	2.00	0.00	2.03	101.5%	58 - 128
Surrogate **	---	---	---	99%	70 - 128

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#) Limits	
					RPD	%REC
Gasoline	2.00	1.98	99.0%	2.5	44.1	58 - 128
Surrogate **	---	---	98%	NA	NA	70 - 128

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:
NA = Not analyzed/not applicable.
* = Values outside of QC limits.
** = 1,2,4-Trichlorobenzene
# = Limits established 8/12/96, MAB

Comments:

K. Hollman
Analyst

McClelland
Approved

MSTVHWS2;MST3237.XLS; 9/25/96

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: OBG-11	Client Project No.	: Westover ARB
Lab Sample No.	: 96-2337-07	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 9/16/96	Matrix	: WATER
Date Prepared	: 9/26/96	Lab File Number(s)	: TVB20925038,39
Date Analyzed	: 9/26/96	Method Blank	: MB2092696
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#) Limits %REC
Gasoline	2.00	0.00	2.24	112.0%	58 - 128
Surrogate **	---	---	---	95%	70 - 128

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#) Limits	
					RPD	%REC
Gasoline	2.00	2.23	111.4%	0.6	44.1	58 - 128
Surrogate **	---	---	98%	NA	NA	70 - 128

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:
NA = Not analyzed/not applicable.
* = Values outside of QC limits.
** = 1,2,4-Trichlorobenzene
# = Limits established 8/12/96, MAB

Comments:

M. Blecha
Analyst

K Hollman
Approved

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4036 Youngfield, Wheat Ridge, CO 80033
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EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: OBG-11	Client Project No.	: Westover ARB
Lab Sample No.	: 96-3237-07	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	EPA Method No.	: 602/8020
Date Received	: 9/16/96	Matrix	: WATER
Date Prepared	: 9/19/96	Lab File Number(s)	: TVBX0919026,27
Date Analyzed	: 9/20/96	Method Blank	: MB2091996
Instrument Name	: TVHBTEX2	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L) MS	Concentration (ug/L) MSD	Comments
Benzene	20.0	0.5	20.5	20.6	
Toluene	20.0	11.0	28.7	29.9	
Chlorobenzene	20.0	0.0	19.5	19.6	
Ethylbenzene	20.0	0.9	20.3	20.4	
m,p-Xylene	20.0	2.4	21.4	21.6	
o-Xylene	20.0	1.4	20.0	20.3	
1,3,5-TMB	20.0	0.0	17.7	18.0	
1,2,4-TMB	20.0	0.0	19.6	19.6	
1,2,3-TMB	20.0	0.0	19.6	19.7	
1,2,3,4-TeMB	20.0	0.0	19.3	19.8	
Surrogate	100.0	96%	95%	95%	% RECOVERY

Compound		MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits RPD	QC# Limits %REC
Benzene		100.0	100.5	0.5	19	59 - 127
Toluene		88.5	94.5	6.6	20	59 - 127
Chlorobenzene		97.5	98.0	0.5	17	67 - 128
Ethylbenzene		97.0	97.5	0.5	20	62 - 125
m,p-Xylene		95.0	96.0	1.0	19	57 - 130
o-Xylene		93.0	94.5	1.6	20	59 - 128
1,3,5-TMB		88.5	90.0	1.7	21	69 - 113
1,2,4-TMB		98.0	98.0	0.0	27	70 - 115
1,2,3-TMB		98.0	98.5	0.5	18	72 - 114
1,2,3,4-TeMB		96.5	99.0	2.6	32	64 - 127
Surrogate		95.0	95.0	NA	NA	70 - 128

#= Limits established 8/12/96, MAB
*= Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments: ______

K. Hollman
Analyst

AmClellan
Approved

EVERGREEN ANALYTICAL, INC.
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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: LCS2091996-GAS	Matrix	: WATER
Date Prepared	: 9/19/96	Method Numbers	: EPA 5030/8015 Modified
Date Analyzed	: 9/20/96	Instrument Name	: TVHBTEX2
Lab File Number(s)	: TVBX0919016		

Compound Name	Theoretical Concentration (mg/L)	LCS Concentration (mg/L)	LCS % Recovery	QC Limit % Recovery
Gasoline	2.00	2.09	104.5	81 - 130
Surrogate Recovery:		99%		70 - 128

QUALIFIERS
B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA = Not Available/Not Applicable.
** = Limits established 8/12/96 for TVHBTEX2. MAB

K. Hollman
Analyst

P. McCalla
Approved

EVERGREEN ANALYTICAL, INC.
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EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number	: LCS2091996-BTEX	Dilution Factor	: 1.00
Date Extracted/Prepared	: 9/19/96	Method	: 602/8020
Date Analyzed	: 9/20/96	Matrix	: Water
Spike Amount (ug/L)	: 20.0	Lab File No.	: TVBX0919017

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	19.7	98.5	74 - 117
Toluene	108-88-3	18.8	94.0	75 - 120
Chlorobenzene	108-90-7	17.8	89.0	75 - 117
Ethyl Benzene	100-41-4	18.9	94.5	80 - 122
m,p-Xylene	108-38-3 106-42-3	36.6	91.5	76 - 122
o-Xylene	95-47-6	18.7	93.5	76 - 120
MTBE	1634-04-4	20.7	103.5	71 - 134
1,3,5-Trimethylbenzene	108-67-8	17.1	85.5	64 - 123
1,2,4-Trimethylbenzene	95-63-6	18.2	91.0	75 - 114
1,2,3-Trimethylbenzene	526-73-8	21.8	109.0	81 - 130
1,2,3,4-Tetramethylbenzene	488-23-3	19.8	99.0	71 - 134
Surrogate Recovery:		97%		70 - 128

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:

E = Extrapolated value. Value exceeds that of the calibration range.
U = Compound analyzed for, but not detected.
B = Compound found in blank and sample. Compare blank and sample data.
NA = Not available/Not analyzed.
** = Limits established 8/12/96 for TVHBTEX2. MAB

K. Hollman
Analyst

[signature]
Approved

LCSBXWS2;LSB20919.XLS; 9/25/96

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 8010 Chlorinated VOC's Method Blank Report

Method Blank	: RB092696	Client Project No.	: 729691.28010 Westover ARB
Date Prepared	: 09/26/96	Lab Project No.	: 96-3237
Date Analyzed	: 09/26/96	Lab File No.	: HALL0926\021F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 92% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW3237.XLS; 10/3/96

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4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: MW-13	Client Project No.	: 729691.28010 Westover ARB
Lab Sample No.	: 96-3237-04	Lab Project No.	: 96-3237
Date Sampled	: 09/14/96	Matrix	: Water
Date Received	: 09/16/96	Lab File No.	: HALL0926\035F0101
Date Prepared	: 09/26/96	Method Blank	: RB092696
Date Analyzed	: 09/27/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	[illegible]
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 92% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form
Method Blank Report

Method Blank Number	: GB092596	**Client Project No.**	: Westover ARB
Date Extracted/Prepared	: 9/25/96	**Lab Work Order**	: 96-3237
Date Analyzed	: 9/25/96	**Dilution Factor**	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS0923043

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3237.XLS

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Methane Report Form

Client Sample Number	: MW-2	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3237-02	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Dilution Factor	: 1.00
Date Received	: 9/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923045

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 74.2 F	Saturation Concentration	Meth
Amount Injected	: 0.5 ml		
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth
Head space created	: 4 ml		
Methane Area	: 0 ug		

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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AF3237.XLS

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4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form

Client Sample Number	: MW-16	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3237-03	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Dilution Factor	: 20.00
Date Received	: 9/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923046

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.60	0.04

Temperature	: 74.1 F	Saturation	Meth	0.145823791
Amount Injected	: 0.025 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.457650084
Head space created	: 4 ml	in Head Space		
Methane Area	: 169.553 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

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EVERGREEN ANALYTICAL, INC.
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(303) 425-6021

Methane Report Form

Client Sample Number	: MW-13	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3237-04	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Dilution Factor	: 1.00
Date Received	: 9/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923047

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.016	0.002

Temperature	:	74.1 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	92.333 ug
Atomic weight(Methane)	:	16 g

Saturation Concentration	Meth	0.003[illegible]4
Concentration in Head Space	Meth	0.01246106

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3237.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form

Client Sample Number	: MW-14	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3237-05	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Dilution Factor	: 1.00
Date Received	: 9/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923048

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.062	0.002

Temperature	: 74.2 F	Saturation Concentration	Meth	0.015083271
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.047328126
Head space created	: 4 ml			
Methane Area	: 350.754 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3237.XLS

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4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MW-14	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3237-05Dup	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Dilution Factor	: 1.00
Date Received	: 9/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923049

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.062	0.002

Temperature	:	74.3 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	351.206 ug
Atomic weight(Methane)	:	16 g

Saturation Concentration	Meth	0.0151 [illegible]
Concentration in Head Space	Meth	0.04738023

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3237.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MW-18	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3237-06	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Dilution Factor	: 50.00
Date Received	: 9/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923050

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	4.1	0.1

Temperature	: 74.3 F	Saturation Concentration	Meth	0.980407903
Amount Injected	: 0.01 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	3.075736931
Head space created	: 4 ml			
Methane Area	: 455.978 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K Holloman
Approved

AF3237.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: OBG-11	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3237-07	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Dilution Factor	: 1.00
Date Received	: 9/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923051

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 74.2 F	Saturation Concentration	Meth	0.000[illegible]1
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.0008507
Head space created	: 4 ml			
Methane Area	: 6.305 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K Hollman
Approved

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form

Client Sample Number	: MW-19	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3237-08	Lab Work Order	: 96-3237
Date Sampled	: 9/14/96	Dilution Factor	: 20.00
Date Received	: 9/16/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923052

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.75	0.04

Temperature	: 74.1 F	Saturation Concentration	Meth	0.181720492
Amount Injected	: 0.025 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.570307479
Head space created	: 4 ml			
Methane Area	: 211.291 ug			
Atomic weight(Methane)	: 16 g			

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst: [signature]

Approved: K. Hollman

AF3237.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: ECS-20	**Client Project No.**	: Westover ARB
Lab Sample Number	: 96-3237-09	**Lab Work Order**	: 96-3237
Date Sampled	: 9/14/96	**Dilution Factor**	: 50.00
Date Received	: 9/16/96	**Method**	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	**Matrix**	: Water
Date Analyzed	: 9/25/96	**Lab File No.**	: GAS0923053

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	2.2	0.1

Temperature	: 74.1 F	Saturation Concentration	Meth	0.5245[illegible]3
Amount Injected	: 0.01 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	1.64614133
Head space created	: 4 ml			
Methane Area	: 243.949 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3237.XLS

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane LCS Report Form

LCS No.	: LCS092596	EPA Method No.	: RSKSOP-175M
Date Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Method Blank	: GB092596
E.A. LCS Source No.	: 1886	Lab File No.	: GAS0923035

Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	412	82	67-85

Spike Recovery: 0 out of (1) outside limits.

Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available.

Analyst

K Hollman
Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/14/96		Client Project ID.	:	Westover ARB 729691.28010
Date Received	: 9/16/96		Lab Project Number	:	96-3237
Date Prepared	: 9/16/96		Method	:	EPA 300.0
Date Analyzed	: 9/16/96		Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride (mg/L)	Dilution Factor
96-3237-02	MW-2	Water	7.3	1
96-3237-03	MW-16	Water	6.7	1
96-3237-03 Duplicate	MW-16 Duplicate	Water	6.7	1
96-3237-04	MW-13	Water	9.1	1
96-3237-05	MW-14	Water	23.9	1
96-3237-06	MW-18	Water	9.3	1
96-3237-07	OBG-11	Water	32.0	1
96-3237-08	MW-19	Water	17.1	1
96-3237-09	ECS-20	Water	50.0	10
Method Blank	(9/16/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3237-03	MW-16 Matrix Spike	10.0	6.7	16.1	94
96-3237-03	MW-16 Matrix Spike Dup	10.0	6.7	15.6	89
MS/MSD RPD					5.4

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	:	9/14/96			Westover ARB
			Client Project ID.	:	729691.28010
Date Received	:	9/16/96	Lab Project Number	:	96-3237
Date Prepared	:	9/16/96	Method	:	EPA 300.0
Date Analyzed	:	9/16/96	Detection Limit	:	0.076 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N (mg/L)	Dilution Factor
96-3237-02	MW-2	Water	<0.076	1
96-3237-03	MW-16	Water	<0.076	1
96-3237-03 Duplicate	MW-16 Duplicate	Water	<0.076	1
96-3237-04	MW-13	Water	<0.076	1
96-3237-05	MW-14	Water	<0.076	1
96-3237-06	MW-18	Water	<0.076	1
96-3237-07	OBG-11	Water	<0.076	1
96-3237-08	MW-19	Water	0.80	1
96-3237-09	ECS-20	Water	<0.076	1
Method Blank	(9/16/96)		<0.076	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3237-03	MW-16 Matrix Spike	10.0	<0.25	9.5	95
96-3237-03	MW-16 Matrix Spike Dup	10.0	<0.25	9.3	94

MS/MSD RPD

* = Quality assurance results reported as Nitrite (NO_2).

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

					Westover ARB
Date Sampled	:	9/14/96	Client Project ID.	:	729691.28010
Date Received	:	9/16/96	Lab Project Number	:	96-3237
Date Prepared	:	9/16/96	Method	:	EPA 300.0
Date Analyzed	:	9/16/96	Detection Limit	:	0.056 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrate-N (mg/L)	Dilution Factor
96-3237-02	MW-2	Water	9.5	10
96-3237-03	MW-16	Water	1.6	1
96-3237-03 Duplicate	MW-16 Duplicate	Water	1.6	1
96-3237-04	MW-13	Water	2.4	1
96-3237-05	MW-14	Water	0.59	1
96-3237-06	MW-18	Water	0.12	1
96-3237-07	OBG-11	Water	2.2	1
96-3237-08	MW-19	Water	2.0	1
96-3237-09	ECS-20	Water	0.71	1
Method Blank	(9/16/96)		<0.056	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3237-03	MW-16 Matrix Spike	10.0	6.7	16.9	100
96-3237-03	MW-16 Matrix Spike Dup	10.0	6.7	16.6	96

MS/MSD RPD

* = Quality assurance results reported as Nitrate (NO_3).

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/14/96	Client Project ID.	:	Westover ARB 729691.28010
Date Received	: 9/16/96	Lab Project Number	:	96-3237
Date Prepared	: 9/16/96	Method	:	EPA 300.0
Date Analyzed	: 9/16/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Sulfate (mg/L)	Dilution Factor
96-3237-02	MW-2	Water	20.9	1
96-3237-03	MW-16	Water	16.5	1
96-3237-03 Duplicate	MW-16 Duplicate	Water	16.5	1
96-3237-04	MW-13	Water	12.0	1
96-3237-05	MW-14	Water	4.8	1
96-3237-06	MW-18	Water	2.3	1
96-3237-07	OBG-11	Water	8.6	1
96-3237-08	MW-19	Water	9.1	1
96-3237-09	ECS-20	Water	3.4	1
Method Blank	(9/16/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3237-03	MW-16 Matrix Spike	10.0	16.5	26.5	100
96-3237-03	MW-16 Matrix Spike Dup	10.0	16.5	26.3	98

MS/MSD RPD

Analyst

Approved

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Analysis Report

Date Sampled	: 9/14/96	Client Project ID.	: 729691.28010
Date Received	: 9/16/96	Lab Project Number	: 96-3237
Date Prepared	: 9/16/96	Method	: EPA 310.1
Date Analyzed	: 9/16/96	Detection Limit	: 5.0 mg $CaCO_3$/L

Evergreen Sample #	Client Sample ID.	Matrix	Total Alkalinity (mg $CaCO_3$/L)	Dilution Factor
96-3237-05	MW-14	Water	66.0	1
96-3237-05 Duplicate	MW-14	Water	66.2	1
Method Blank	(9/16/96)		<5.0	

Quality Assurance

Reference	True Value (mg$CaCO_3$/L)	Result (mg$CaCO_3$/L)	% Recovery
ERA Minerals Lot # 9970	180	179	99

Analyst

Approved

Evergreen Analytical, Inc.

96-3252

WORK ORDER Summary

24-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3252-06A	MP-11	% Moisture for dry weight calculation		Soil	Out	14-Sep-96	17-Sep-96	20-Sep-96	12-Oct-96
96-3252-07A	MP-14	% Moisture for dry weight calculation			2			20-Sep-96	12-Oct-96
96-3252-17A	SS-2	% Moisture for dry weight calculation				15-Sep-96		20-Sep-96	13-Oct-96
96-3252-18A	SS-3	% Moisture for dry weight calculation						20-Sep-96	13-Oct-96
96-3252-19A	SS-4	% Moisture for dry weight calculation						20-Sep-96	13-Oct-96
96-3252-20A	SS-5 (4.5)	% Moisture for dry weight calculation						20-Sep-96	13-Oct-96
96-3252-21A	SS-5 (7')	% Moisture for dry weight calculation						20-Sep-96	13-Oct-96
96-3252-22A	SS-5 (12')	% Moisture for dry weight calculation			Out			20-Sep-96	13-Oct-96
96-3252-02G	OBG-7	Anions by IC Cl,NO2,NO3,SO4		Groundwater	CL4	14-Sep-96		01-Oct-96	16-Sep-96
96-3252-03G	MW-114	Anions by IC Cl,NO2,NO3,SO4						01-Oct-96	16-Sep-96
96-3252-04G	ECS-22	Anions by IC Cl,NO2,NO3,SO4						01-Oct-96	16-Sep-96
96-3252-05G	MW-115	Anions by IC Cl,NO2,NO3,SO4						01-Oct-96	16-Sep-96
96-3252-08I	MP-11S	Anions by IC Cl,NO2,NO3,SO4				15-Sep-96		01-Oct-96	17-Sep-96
96-3252-09I	MP-11D	Anions by IC Cl,NO2,NO3,SO4						01-Oct-96	17-Sep-96
96-3252-10G	MP-12	Anions by IC Cl,NO2,NO3,SO4						01-Oct-96	17-Sep-96
96-3252-11G	MP-13	Anions by IC Cl,NO2,NO3,SO4						01-Oct-96	17-Sep-96

# = Special list. See sample comments or test information.
HT = Holding Time expiration date.

JM
9/24/96

Evergreen Analytical, Inc.

96-3252

WORK ORDER Summary

24-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3252-12G	OBG-8	Anions by IC Cl,NO2,NO3,SO4		Groundwater	CL4	15-Sep-96	17-Sep-96	01-Oct-96	17-Sep-96
96-3252-13G	OBG-10	Anions by IC Cl,NO2,NO3,SO4						01-Oct-96	17-Sep-96
96-3252-15G	MP-14(S)	Anions by IC Cl,NO2,NO3,SO4						01-Oct-96	17-Sep-96
96-3252-16G	MP-14(D)	Anions by IC Cl,NO2,NO3,SO4						01-Oct-96	17-Sep-96
96-3252-01A	Trip Blank	BTEX (Parsons List)		Water	2			20-Sep-96	
96-3252-02A	OBG-7	BTEX (Parsons List)		Groundwater		14-Sep-96		20-Sep-96	28-Sep-96
96-3252-03A	MW-114	BTEX (Parsons List)						20-Sep-96	28-Sep-96
96-3252-04A	ECS-22	BTEX (Parsons List)						20-Sep-96	28-Sep-96
96-3252-05A	MW-115	BTEX (Parsons List)						20-Sep-96	28-Sep-96
96-3252-07A	MP-14	BTEX (Parsons List)		Soil				20-Sep-96	28-Sep-96
96-3252-08A	MP-11S	BTEX (Parsons List)		Groundwater		15-Sep-96		20-Sep-96	29-Sep-96
96-3252-09A	MP-11D	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-10A	MP-12	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-11A	MP-13	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-12A	OBG-8	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-13A	OBG-10	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-14A	Ambient	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-15A	MP-14(S)	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-16A	MP-14(D)	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-17A	SS-2	BTEX (Parsons List)		Soil				20-Sep-96	29-Sep-96

# = S[illegible] list. See sample comments or test information.
HT = [illegible]ng Time expiration date.

Evergreen Analytical, Inc. **96-3252**

WORK ORDER Summary

24-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3252-18A	SS-3	BTEX (Parsons List)		Soil	2	15-Sep-96	17-Sep-96	20-Sep-96	29-Sep-96
96-3252-19A	SS-4	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-20A	SS-5 (4.5)	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-21A	SS-5 (7')	BTEX (Parsons List)						20-Sep-96	29-Sep-96
96-3252-02D	OBG-7	Methane		Groundwater		14-Sep-96		01-Oct-96	28-Sep-96
96-3252-03D	MW-114	Methane						01-Oct-96	28-Sep-96
96-3252-04D	ECS-22	Methane						01-Oct-96	28-Sep-96
96-3252-05D	MW-115	Methane						01-Oct-96	28-Sep-96
96-3252-08D	MP-11S	Methane				15-Sep-96		01-Oct-96	29-Sep-96
96-3252-09D	MP-11D	Methane						01-Oct-96	29-Sep-96
96-3252-10D	MP-12	Methane						01-Oct-96	29-Sep-96
96-3252-11D	MP-13	Methane						01-Oct-96	29-Sep-96
96-3252-12D	OBG-8	Methane						01-Oct-96	29-Sep-96
96-3252-13D	OBG-10	Methane						01-Oct-96	29-Sep-96
96-3252-15D	MP-14(S)	Methane						01-Oct-96	29-Sep-96
96-3252-16D	MP-14(D)	Methane						01-Oct-96	29-Sep-96
96-3252-08G	MP-11S	Purgeable Halocarbons 8010			9			01-Oct-96	29-Sep-96
96-3252-09G	MP-11D	Purgeable Halocarbons 8010						01-Oct-96	29-Sep-96
96-3252-13H	OBG-10	Total Alkalinity			CL4			01-Oct-96	29-Sep-96
96-3252-06A	MP-11	Total Organic Carbon		Soil	Out	14-Sep-96		01-Oct-96	21-Sep-96
96-3252-07B	MP-14	Total Organic Carbon						01-Oct-96	21-Sep-96
96-3252-17B	SS-2	Total Organic Carbon				15-Sep-96		01-Oct-96	22-Sep-96
96-3252-18B	SS-3	Total Organic Carbon						01-Oct-96	22-Sep-96

# = Special list. See sample comments or test information.
HT = Holding Time expiration date.

Evergreen Analytical, Inc. **96-3252**

WORK ORDER Summary

24-Sep-96

Report To: Dave Moutoux
Parsons Engineering Science
1700 Broadway Suite 900
Denver, CO 80290

Client Project ID: 729691.28010 Westover ARB

Phone: (303) 831-8100
FAX: (303) 831-8208

Comments:

Sample ID	Client Sample ID	Analysis	#	Matrix	Loc	Collection	Received	Due	HT
96-3252-19B	SS-4	Total Organic Carbon		Soil	Out	15-Sep-96	17-Sep-96	01-Oct-96	22-Sep-96
96-3252-22A	SS-5 (12')	Total Organic Carbon						01-Oct-96	22-Sep-96
96-3252-01A	Trip Blank	Total Volatile Hydrocarbons		Water	2			20-Sep-96	
96-3252-02A	OBG-7	Total Volatile Hydrocarbons		Groundwater		14-Sep-96		20-Sep-96	28-Sep-96
96-3252-03A	MW-114	Total Volatile Hydrocarbons						20-Sep-96	28-Sep-96
96-3252-04A	ECS-22	Total Volatile Hydrocarbons						20-Sep-96	28-Sep-96
96-3252-05A	MW-115	Total Volatile Hydrocarbons						20-Sep-96	28-Sep-96
96-3252-08A	MP-11S	Total Volatile Hydrocarbons				15-Sep-96		20-Sep-96	29-Sep-96
96-3252-09A	MP-11D	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-10A	MP-12	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-11A	MP-13	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-12A	OBG-8	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-13A	OBG-10	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-14A	Ambient	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-15A	MP-14(S)	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-16A	MP-14(D)	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-17A	SS-2	Total Volatile Hydrocarbons		Soil				20-Sep-96	29-Sep-96
96-3252-18A	SS-3	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-19A	SS-4	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-20A	SS-5 (4.5)	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96
96-3252-21A	SS-5 (7')	Total Volatile Hydrocarbons						20-Sep-96	29-Sep-96

# = Sp[illegible]ist. See sample comments or test information.
HT = H[illegible]ing Time expiration date.

CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

Evergreen Analytical Inc.
4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

COMPANY Parsons ES
ADDRESS 1700 Broadway, STE 900
CITY Denver STATE CO ZIP 80290
PHONE# 831-8100 FAX # 831-8208 FAX RESULTS Y / N

CLIENT CONTACT (print) Dave Mostoux
CLIENT PROJ. I.D. Westover ARB
EAL. QUOTE # ____ P.O.# ____
TURNAROUND REQUIRED* ☐ STD (2 wks) ☐ UST
☐ Other (Specify)*
*expedited turnaround subject to additional fee

Sampler Name:
(signature) Saskia Hoffer
(print) Saskia Hoffer

Please **PRINT** all information:

EAL use only
Do not write in shaded area
W.O. # 96-325
B.O.F. #
C/S (O) 602 / CO
C/S (I) 602 / CO
Cooler Temp. °C 11
Seals Intact Y / N / NA
Samples Pres. Y / N / NA
Headspace Y / N / NA

CLIENT SAMPLE IDENTIFICATION	DATE SAMPLED	TIME	No. of Containers	MATRIX: Water-Drinking/Discharge/Ground (circle)	MATRIX: Soil / Solid / Air / Gas	MATRIX: Oil / Sludge / Multi-phase	TCLP VOA/BNA/Pest/Herb/Metals (circle)	VOA 8260/624/524.2 (circle)	BNA 8270/625 (circle)	Pesticides 8080/608 (circle)	Pest/PCBs 8080/608/508 (circle)	PCB Screen	Herbicides 8150/515 (circle)	BTEX 8020/602 (circle)/MTBE (circle) +TMB	TVPH 8015mod. (Gasoline)	TEPH 8015mod. (Diesel)	Total Metals-DW / NPDES / SW846 (circle & list metals below)	Dissolved Metals - DW / SW846 (circle & list metals below)	Oil & Grease 413.1	TRPH 418.1	Methane	alkalinity	TOC	VOC	Cl, NO2, NO3, SO4=	EAL use only
TripBlank	-	-	1	X										X	X											01A
OBG-7	9/14/96	1430	7	X										X	X						X				X	02 A-G
MW-114	9/14/96	1500	7	X										X	X						X				X	03
ECS-22	9/14/96	1600	7	X										X	X						X				X	04
MW-115	9/14/96	1630	7	X										X	X						X				X	05
MP-11	9/14/96	1400	1		X																		X			06 A 4WM
MP-14	9/14/96	1700	2		X									X									X			07 A/B 4WM
MP-11S	9/15/96	0745	7	X										X	X						X			X	X	08 A-GI
MP-11D	9/15/96	0800	7	X										X	X						X			X	X	09
MP-12	9/15/96	0845	7	X										X	X						X				X	10 A-G
Sample Fraction														A-C							D-F			G/H	G/I	Loc 9,2,CL4
Instructions:														40V							40V			40 V	125 P	Cont

~~One of 3 vials for BTEX/TVH arrived broken, 'C' not used as EAL sample no.~~ MM 9/27/96 MM 9/24/96

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Saskia Hoffer	9/16 1700	FEDEX	9/16 1700	FedEx	9/17/96 09:15	P. Black	9/17/96

CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

Evergreen Analytical Inc.
4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

COMPANY SAA
ADDRESS
CITY STATE ZIP
PHONE# FAX #
FAX RESULTS Y / N

CLIENT CONTACT (print)
CLIENT PROJ. I.D. SAA
EAL. QUOTE # P.O.#
TURNAROUND REQUIRED* ☐ STD (2 wks) ☐ UST
☐ Other (Specify)*
*expedited turnaround subject to additional fee

Sampler Name:
(signature) [signature]
(print) SASKIA HOFFER

Please **PRINT** all information:

CLIENT SAMPLE IDENTIFICATION	DATE SAMPLED	TIME	No. of Containers	MATRIX: Water-Drinking/Discharge/Ground (circle)	MATRIX: Soil/ Solid / Air / Gas	MATRIX: Oil / Sludge / Multi-phase	TCLP VOA/BNA/Pest/Herb/Metals (circle)	VOA 8260/624/524.2 (circle)	BNA 8270/625 (circle)	Pesticides 8080/608 (circle)	Pest/PCBs 8080/608/508 (circle)	PCB Screen	Herbicides 8150/515 (circle)	BTEX 8020/602 (circle)/MTBE (circle)	TVPH 8015mod. (Gasoline)	TEPH 8015mod. (Diesel)	Total Metals-DW / NPDES / SW846 (circle & list metals below)	Dissolved Metals - DW / SW846 (circle & list metals below)	Oil & Grease 413.1	TRPH 418.1	METHANE	Anions Cl- NO2 NO3 SO4	Alkalinity	TOC			EAL use only Do not write in shaded area
MP-13	9/15/96	9:20	7	X										X	X						X	X					11A-G
OBG-8	9/15/96	10:00	7	X										X	X						X	X					12A-G
* OBG-10	9/15/96	10:30	8	X										X	X						X	X	X				13A-H
Ambient	9/15/96	1030	3	X										X	X												14A-C
MP-14(S)	9/15/96	11:20	7	X										X	X						X	X					15A-G
* MP-14(D)	9/15/96	11:00	7	X										X	X						X	X					16A-G
SS-2	9/15/96	1330	2		X									X	X									X			17A/B 4wm
SS-3	9/15/96	1430	2		X									X	X									X			18
SS-4	9/15/96	1515	2		X									X	X									X			19
SS-5(4.5)	9/15/96	1530	1		X									X	X												20A
Sample Fraction														A	C						DF	G	H				Loc 9,2,CL4
Instructions:														40V							40V	125 P	250 P				Cont

EAL use only — W.O. # 96-3252; B.O.F. #; C/S (O); C/S (I); Cooler Temp. °C; Seals Intact Y / N / NA; Samples Pres. Y / N / NA; Headspace Y / N / NA

→ One of 3 vials for BTEX/TVH arrived broken. 'C' not used as EAL sample no. – mpm 9/17/96.
→ * OBG-10 alkalinity bottle leaked, rec'd only 1/4 full. Was inverted w/ loose cap. – mpm 9/17/96

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
[signature]	9/16	Fedex	9/16	Fedex	9/17/96	[signature]	9/17/96

CHAIN OF CUSTODY RECORD / ANALYTICAL SERVICES REQUEST

Evergreen Analytical Inc.
4036 Youngfield St.
Wheat Ridge, Colorado 80033
(303) 425-6021
FAX (303) 425-6854
(800) 845-7400

COMPANY ______
ADDRESS SAA
CITY ______ STATE ______ ZIP ______
PHONE# ______ FAX # ______ FAX RESULTS Y / N

CLIENT CONTACT (print) SAA
CLIENT PROJ. I.D. ______
EAL. QUOTE # ______ P.O.# ______
TURNAROUND REQUIRED* ☐ STD (2 wks) ☐ UST
☐ Other (Specify)* ______
*expedited turnaround subject to additional fee

Sampler Name:
(signature) Saskia Hoffer
(print) Saskia Hoffer

Please **PRINT** all information:

CLIENT SAMPLE IDENTIFICATION	DATE SAMPLED	TIME	No. of Containers	MATRIX: Water-Drinking/Discharge/Ground (circle)	MATRIX: Soil / Solid / Air / Gas	MATRIX: Oil / Sludge / Multi-phase	TCLP VOA/BNA/Pest/Herb/Metals (circle)	VOA 8260/624/524.2 (circle)	BNA 8270/625 (circle)	Pesticides 8080/608 (circle)	Pest/PCBs 8080/608/508 (circle)	PCB Screen	Herbicides 8150/515 (circle)	BTEX 8020/602 (circle)/MTBE (circle) + TMB	TVPH 8015mod. (Gasoline)	TEPH 8015mod. (Diesel)	Total Metals-DW / NPDES / SW846 (circle & list metals below)	Dissolved Metals - DW / SW846 (circle & list metals below)	Oil & Grease 413.1	TRPH 418.1	TOC	EAL use only
SS-5 (7')	9/15/96	1600	1		X									X	X							21A 4WM
SS-5 (12')	9/15/96	1600	1		X																X	22A 4WM
Sample Fraction																						Loc 2, CL4
Instructions:																						Cont

EAL use only — Do not write in shaded area
W.O. # 96-325
B.O.F. # ______
C/S (O) ______ / ______
C/S (I) ______ / ______
Cooler Temp. °C ______
Seals Intact Y / N / NA
Samples Pres. Y / N / NA
Headspace Y / N / NA

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time	Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Date/Time
Saskia Hoffer	9/16 1700	FEDEX	9/16 1700	Fedex	9/17/96 0915	PH Black	9/17/96 0915

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB1092096	Client Project Number	: Westover ARB
Date Prepared	: 9/20/96	Lab Work Order	: 96-3252
Dilution Factor	: 1.0	Matrix	: Water
		Lab File Number	: TVB10920003

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/L
Benzene	71-43-2	9/20/96	U	0.4	ug/L
Toluene	108-88-3	9/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/L
FID Surrogate Recovery:		100%		70%-121%	(Limits)
PID Surrogate Recovery:		104%		82%-115%	(Lin

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K Hellman
Analyst

McClellan
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB1092196	Client Project Number	: Westover ARB
Date Prepared	: 9/21/96	Lab Work Order	: 96-3252
Dilution Factor	: 1.0	Matrix	: Water
		Lab File Number	: TVB10920037

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/21/96	U	0.1	mg/L
Benzene	71-43-2	9/21/96	U	0.4	ug/L
Toluene	108-88-3	9/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	U	0.5	ug/L
FID Surrogate Recovery:		100%		70%-121%	(Limits)
PID Surrogate Recovery:		102%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

K. Hollma
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB1092396B	Client Project Number	: Westover ARB
Date Prepared	: 9/23/96	Lab Work Order	: 96-3252
Dilution Factor	: 1.0	Matrix	: Water
		Lab File Number	: TVB10923005

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/23/96	U	0.1	mg/L
Benzene	71-43-2	NA	NA	NA	NA
Toluene	108-88-3	NA	NA	NA	NA
Chlorobenzene	108-90-7	NA	NA	NA	NA
Ethyl Benzene	100-41-4	NA	NA	NA	NA
Total Xylenes (m,p,o)	1330-20-7	NA	NA	NA	NA
1,3,5-Trimethylbenzene	108-67-8	NA	NA	NA	NA
1,2,4-Trimethylbenzene	95-63-6	NA	NA	NA	NA
1,2,3-Trimethylbenzene	526-73-8	NA	NA	NA	NA
1,2,3,4-Tetramethylbenzene	488-23-3	NA	NA	NA	NA
FID Surrogate Recovery:		100%		70%-121%	(Limi
PID Surrogate Recovery:	NA			82%-115%	(Lim

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

A McClelle
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB1092396C	Client Project Number	: Westover ARB
Date Prepared	: 9/23/96	Lab Work Order	: 96-3252
Dilution Factor	: 1.0	Matrix	: Water
		Lab File Number	: TVB10923015

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/23/96	U	0.1	mg/L
Benzene	71-43-2	9/23/96	U	0.4	ug/L
Toluene	108-88-3	9/23/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/23/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/23/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/23/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/23/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/23/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/23/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/23/96	U	0.5	ug/L
FID Surrogate Recovery:		99%		70%-121%	(Limits)
PID Surrogate Recovery:		105%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

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B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

K Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report
Method Blank Report

Method Blank Number	: MB1092496	Client Project Number	: Westover ARB
Date Prepared	: 9/24/96	Lab Work Order	: 96-3252
Dilution Factor	: 1.0	Matrix	: Water
		Lab File Number	: TVB10923028

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/24/96	U	0.1	mg/L
Benzene	71-43-2	9/24/96	U	0.4	ug/L
Toluene	108-88-3	9/24/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/24/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/24/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/24/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/24/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/24/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/24/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/24/96	U	0.5	ug/L
FID Surrogate Recovery:		100%		70%-121%	
PID Surrogate Recovery:		103%		82%-115%	

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: Trip Blank	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-01	Lab Work Order	: 96-3252
Date Sampled	: NA	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920025
Date Prepared	: 9/20/96	Method Blank	: MB1092096
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/L
Benzene	71-43-2	9/20/96	U	0.4	ug/L
Toluene	108-88-3	9/20/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/L
FID Surrogate Recovery:		98%		70%-121%	(Limits)
PID Surrogate Recovery:		103%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hillman
Analyst

P. McClella
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	OBG-7	Client Project Number	:	Westover ARB
Lab Sample Number	:	96-3252-02	Lab Work Order	:	96-3252
Date Sampled	:	9/14/96	Matrix	:	Water
Date Received	:	9/17/96	Lab File Number(s)	:	TVB10920027
Date Prepared	:	9/20/96	Method Blank	:	MB1092096
FID Dilution Factor	:	1.0			
PID Dilution Factor	:	1.0			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	0.8	0.1	mg/L
Benzene	71-43-2	9/20/96	U	0.4	ug/L
Toluene	108-88-3	9/20/96	1.5	0.4	ug/L
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/20/96	25	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/20/96	69	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/20/96	3.0	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/20/96	5.3	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/20/96	1.7	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/L
FID Surrogate Recovery:		98%		70%-121%	(Lin
PID Surrogate Recovery:		102%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

K Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	MW-114	Client Project Number	:	Westover ARB
Lab Sample Number	:	96-3252-03	Lab Work Order	:	96-3252
Date Sampled	:	9/14/96	Matrix	:	Water
Date Received	:	9/17/96	Lab File Number(s)	:	TVB10920041
Date Prepared	:	9/21/96	Method Blank	:	MB1092196
FID Dilution Factor	:	1.0			
PID Dilution Factor	:	1.0			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/21/96	1.0	0.1	mg/L
Benzene	71-43-2	9/21/96	U	0.4	ug/L
Toluene	108-88-3	9/21/96	1.6	0.4	ug/L
Chlorobenzene	108-90-7	9/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/21/96	28	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/21/96	96	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/21/96	7.3	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/21/96	15	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	2.6	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	U	0.5	ug/L
FID Surrogate Recovery:		98%		70%-121%	(Limits)
PID Surrogate Recovery:		104%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: ECS-22	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-04	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920047
Date Prepared	: 9/21/96	Method Blank	: MB1092196
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/21/96	U	0.1	mg/L
Benzene	71-43-2	9/21/96	U	0.4	ug/L
Toluene	108-88-3	9/21/96	0.4	0.4	ug/L
Chlorobenzene	108-90-7	9/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	0.9	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	U	0.5	ug/L
FID Surrogate Recovery:		97%		70%-121%	(Li
PID Surrogate Recovery:		103%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

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RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

K. Hollman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MW-115	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-05	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920048
Date Prepared	: 9/21/96	Method Blank	: MB1092196
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/21/96	U	0.1	mg/L
Benzene	71-43-2	9/21/96	U	0.4	ug/L
Toluene	108-88-3	9/21/96	0.4	0.4	ug/L
Chlorobenzene	108-90-7	9/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	0.7	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	U	0.5	ug/L
FID Surrogate Recovery:		96%		70%-121%	(Limits)
PID Surrogate Recovery:		102%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hollman
Analyst

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-14	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-07	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	Matrix	: Soil
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920011
Date Prepared	: 9/20/96	Method Blank	: MB1092096
FID Dilution Factor	: 1.0	Soil Extracted?	: NO
PID Dilution Factor	: 1.0	Soil Moisture	: 10.87%

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	NA	NA	NA	NA
Benzene	71-43-2	9/20/96	U	0.4	ug/kg
Toluene	108-88-3	9/20/96	U	0.4	ug/kg
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/kg
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/kg
Total Xylenes (m,p,o)	1330-20-7	9/20/96	U	0.4	ug/kg
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/kg
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/kg
1,2,3-Trimethylbenzene	526-73-8	9/20/96	0.8	0.4	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.6	ug/kg
FID Surrogate Recovery:	NA			50%-132%	(Li
PID Surrogate Recovery:		100%		72%-118%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

K. Hollman
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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-11S	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-08	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920049
Date Prepared	: 9/21/96	Method Blank	: MB1092196
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/21/96	U	0.1	mg/L
Benzene	71-43-2	9/21/96	U	0.4	ug/L
Toluene	108-88-3	9/21/96	1.8	0.4	ug/L
Chlorobenzene	108-90-7	9/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/21/96	1.1	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	1.5	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	U	0.5	ug/L
FID Surrogate Recovery:		94%		70%-121%	(Limits)
PID Surrogate Recovery:		102%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-11D	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-09	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920050
Date Prepared	: 9/21/96	Method Blank	: MB1092196
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/21/96	1.5	0.1	mg/L
Benzene	71-43-2	9/21/96	34	0.4	ug/L
Toluene	108-88-3	9/21/96	2.1	0.4	ug/L
Chlorobenzene	108-90-7	9/21/96	0.7	0.4	ug/L
Ethyl Benzene	100-41-4	9/21/96	8.9	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/21/96	7.8	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/21/96	9.3	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/21/96	25	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	4.2	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	U	0.5	ug/L
FID Surrogate Recovery:		96%		70%-121%	(Lim
PID Surrogate Recovery:		104%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

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(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	:	MP-12	Client Project Number	:	Westover ARB
Lab Sample Number	:	96-3252-10	Lab Work Order	:	96-3252
Date Sampled	:	9/15/96	Matrix	:	Water
Date Received	:	9/17/96	Lab File Number(s)	:	TVB10923006,021*
Date Prepared	:	9/21,23/96	Method Blank	:	MB1092396B,C
FID Dilution Factor	:	25			MB1092196
PID Dilution Factor	:	1.0; 50			

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/23/96	13	2.5	mg/L
Benzene	71-43-2	9/23/96	2100	20	ug/L
Toluene	108-88-3	9/23/96	300	20	ug/L
Chlorobenzene	108-90-7	9/21/96	6.4	0.4	ug/L
Ethyl Benzene	100-41-4	9/23/96	1000	20	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/23/96	4900	20	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/23/96	43	20	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/23/96	140	20	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	42	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	7.9	0.5	ug/L
FID Surrogate Recovery:		103%		70%-121%	(Limits)
PID Surrogate Recovery:		116%,102%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: * = and TVB10920051

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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EVERGREEN ANALYTICAL, INC.
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(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-13	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-11	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920055
Date Prepared	: 9/21/96	Method Blank	: MB1092196
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/21/96	U	0.1	mg/L
Benzene	71-43-2	9/21/96	U	0.4	ug/L
Toluene	108-88-3	9/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	U	0.5	ug/L
FID Surrogate Recovery:		97%		70%-121%	(Lin
PID Surrogate Recovery:		104%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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EVERGREEN ANALYTICAL, INC.
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(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: OBG-8	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-12	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10923007,022*
Date Prepared	: 9/21,23/96	Method Blank	: MB1092396B,C
FID Dilution Factor	: 10		MB1092196
PID Dilution Factor	: 1.0; 20		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/23/96	3.5	1.0	mg/L
Benzene	71-43-2	9/21/96	U	0.4	ug/L
Toluene	108-88-3	9/21/96	5.7	0.4	ug/L
Chlorobenzene	108-90-7	9/21/96	1.3	0.4	ug/L
Ethyl Benzene	100-41-4	9/23/96	250	8.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/23/96	930	8.0	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/21/96	33	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/21/96	82	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	13	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	U	0.5	ug/L
FID Surrogate Recovery:		103%		70%-121%	(Limits)
PID Surrogate Recovery:		99%, 102%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: * = and TVB1920056

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: OBG-10	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-13	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920057
Date Prepared	: 9/21/96	Method Blank	: MB1092196
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/21/96	0.9	0.1	mg/L
Benzene	71-43-2	9/21/96	U	0.4	ug/L
Toluene	108-88-3	9/21/96	9.0	0.4	ug/L
Chlorobenzene	108-90-7	9/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/21/96	15	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/21/96	52	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/21/96	9.2	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/21/96	18	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	9.0	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	0.9	0.5	ug/L
FID Surrogate Recovery:		100%		70%-121%	(Lim
PID Surrogate Recovery:		105%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

K. Hollman
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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: Ambient	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-14	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920059
Date Prepared	: 9/21/96	Method Blank	: MB1092196
FID Dilution Factor	: 1.0		
PID Dilution Factor	: 1.0		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/21/96	U	0.1	mg/L
Benzene	71-43-2	9/21/96	U	0.4	ug/L
Toluene	108-88-3	9/21/96	U	0.4	ug/L
Chlorobenzene	108-90-7	9/21/96	U	0.4	ug/L
Ethyl Benzene	100-41-4	9/21/96	U	0.4	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/21/96	U	0.4	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/21/96	U	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/21/96	U	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/21/96	U	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/21/96	U	0.5	ug/L
FID Surrogate Recovery:		97%		70%-121%	(Limits)
PID Surrogate Recovery:		103%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-14(S)	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-15	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10923008,23*
Date Prepared	: 9/21,23/96	Method Blank	: MB1092396B,C
FID Dilution Factor	: 25		MB1092196
PID Dilution Factor	: 1.0; 100		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/23/96	25	2.5	mg/L
Benzene	71-43-2	9/22/96	U	0.4	ug/L
Toluene	108-88-3	9/23/96	10000	40	ug/L
Chlorobenzene	108-90-7	9/22/96	6.6	0.4	ug/L
Ethyl Benzene	100-41-4	9/23/96	560	40	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/23/96	3000	40	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/22/96	30	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/22/96	39	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/22/96	13	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/22/96	77	0.5	ug/L
FID Surrogate Recovery:		104%		70%-121%	(Li
PID Surrogate Recovery:		101%, 103%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: * = and TVB10920060

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Analyst

P. McClella
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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: MP-14(D)	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-16	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Water
Date Received	: 9/17/96	Lab File Number(s)	: TVB10923024*
Date Prepared	: 9/21,23/96	Method Blank	: MB1092396C
FID Dilution Factor	: 1.0		MB1092196
PID Dilution Factor	: 1.0; 20		

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/22/96	3.8	0.1	mg/L
Benzene	71-43-2	9/22/96	U	0.4	ug/L
Toluene	108-88-3	9/23/96	460	8.0	ug/L
Chlorobenzene	108-90-7	9/22/96	1.9	0.4	ug/L
Ethyl Benzene	100-41-4	9/23/96	290	8.0	ug/L
Total Xylenes (m,p,o)	1330-20-7	9/23/96	1500	8.0	ug/L
1,3,5-Trimethylbenzene	108-67-8	9/22/96	12	0.4	ug/L
1,2,4-Trimethylbenzene	95-63-6	9/22/96	23	0.4	ug/L
1,2,3-Trimethylbenzene	526-73-8	9/22/96	9.9	0.4	ug/L
1,2,3,4-Tetramethylbenzene	488-23-3	9/22/96	0.5 U	0.5	ug/L
FID Surrogate Recovery:		95%		70%-121%	(Limits)
PID Surrogate Recovery:		99%, 104%		82%-115%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: * = and TVB10920061

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

K. Hellman
Analyst

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EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: SS-2	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-17	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Soil
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920012
Date Prepared	: 9/20/96	Method Blank	: MB1092096
FID Dilution Factor	: 1.0	Soil Extracted?	: NO
PID Dilution Factor	: 1.0	Soil Moisture	: 9.54%

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/kg
Benzene	71-43-2	9/20/96	U	0.4	ug/kg
Toluene	108-88-3	9/20/96	0.8	0.4	ug/kg
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/kg
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/kg
Total Xylenes (m,p,o)	1330-20-7	9/20/96	0.4	0.4	ug/kg
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/kg
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/kg
1,2,3-Trimethylbenzene	526-73-8	9/20/96	0.6	0.4	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.6	ug/kg
FID Surrogate Recovery:		54%		50%-132%	(Lim
PID Surrogate Recovery:		81%		72%-118%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: SS-3	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-18	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Soil
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920013
Date Prepared	: 9/20/96	Method Blank	: MB1092096
FID Dilution Factor	: 1.0	Soil Extracted?	: NO
PID Dilution Factor	: 1.0	Soil Moisture	: 4.06%

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/kg
Benzene	71-43-2	9/20/96	U	0.4	ug/kg
Toluene	108-88-3	9/20/96	U	0.4	ug/kg
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/kg
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/kg
Total Xylenes (m,p,o)	1330-20-7	9/20/96	U	0.4	ug/kg
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/kg
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/kg
1,2,3-Trimethylbenzene	526-73-8	9/20/96	0.5	0.4	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/kg
FID Surrogate Recovery:		83%		50%-132%	(Limits)
PID Surrogate Recovery:		90%		72%-118%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: SS-4	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-19	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Soil
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920014
Date Prepared	: 9/20/96	Method Blank	: MB1092096
FID Dilution Factor	: 1.0	Soil Extracted?	: NO
PID Dilution Factor	: 1.0	Soil Moisture	: 9.49%

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/kg
Benzene	71-43-2	9/20/96	U	0.4	ug/kg
Toluene	108-88-3	9/20/96	1.2	0.4	ug/kg
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/kg
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/kg
Total Xylenes (m,p,o)	1330-20-7	9/20/96	0.7	0.4	ug/kg
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/kg
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/kg
1,2,3-Trimethylbenzene	526-73-8	9/20/96	U	0.4	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.6	ug/kg
FID Surrogate Recovery:		14% *		50%-132%	(Limits
PID Surrogate Recovery:		42% *		72%-118%	(Limits

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments: * = See TVB10923010; for low surrogate confirmation.

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: SS-5(4.5)	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-20	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Soil
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920015
Date Prepared	: 9/20/96	Method Blank	: MB1092096
FID Dilution Factor	: 1.0	Soil Extracted?	: NO
PID Dilution Factor	: 1.0	Soil Moisture	: 14.71%

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/kg
Benzene	71-43-2	9/20/96	U	0.5	ug/kg
Toluene	108-88-3	9/20/96	U	0.5	ug/kg
Chlorobenzene	108-90-7	9/20/96	U	0.5	ug/kg
Ethyl Benzene	100-41-4	9/20/96	U	0.5	ug/kg
Total Xylenes (m,p,o)	1330-20-7	9/20/96	U	0.5	ug/kg
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.5	ug/kg
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.5	ug/kg
1,2,3-Trimethylbenzene	526-73-8	9/20/96	U	0.5	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.6	ug/kg
FID Surrogate Recovery:		82%		50%-132%	(Limits)
PID Surrogate Recovery:		92%		72%-118%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA = Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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Methods 602/8020 and 5030/8015 Modified Data Report

Client Sample Number	: SS-5(7')	Client Project Number	: Westover ARB
Lab Sample Number	: 96-3252-21	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Matrix	: Soil
Date Received	: 9/17/96	Lab File Number(s)	: TVB10920016
Date Prepared	: 9/20/96	Method Blank	: MB10921096
FID Dilution Factor	: 1.0	Soil Extracted?	: NO
PID Dilution Factor	: 1.0	Soil Moisture	: 7.90%

Compound Name	Cas Number	Analysis Date	Sample Concentration	RL	Units
TVH-Gasoline	----	9/20/96	U	0.1	mg/kg
Benzene	71-43-2	9/20/96	U	0.4	ug/kg
Toluene	108-88-3	9/20/96	U	0.4	ug/kg
Chlorobenzene	108-90-7	9/20/96	U	0.4	ug/kg
Ethyl Benzene	100-41-4	9/20/96	U	0.4	ug/kg
Total Xylenes (m,p,o)	1330-20-7	9/20/96	U	0.4	ug/kg
1,3,5-Trimethylbenzene	108-67-8	9/20/96	U	0.4	ug/kg
1,2,4-Trimethylbenzene	95-63-6	9/20/96	U	0.4	ug/kg
1,2,3-Trimethylbenzene	526-73-8	9/20/96	U	0.4	ug/kg
1,2,3,4-Tetramethylbenzene	488-23-3	9/20/96	U	0.5	ug/kg
FID Surrogate Recovery:		98%		50%-132%	(Li
PID Surrogate Recovery:		101%		72%-118%	(Limits)

Notes: Total Xylenes consist of three isomers, two of which co-elute. The Xylene RL is for a single peak.

Comments:

QUALIFIERS and DEFINITIONS:

E = Extrapolated value. Value exceeds calibration range.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
J = Indicates an estimated value when the compound is detected, but is below the Reporting Limit.
RL = Reporting Limit.
NA =Not Available/Not Applicable.
PID = Photoionization detector.
FID = Flame ionization detector.
TVH = Total Volatile Hydrocarbons.

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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: OBG-7	Client Project No	: Westover ARB
Lab Sample No.	: 96-3252-02	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 9/17/96	Matrix	: WATER
Date Prepared	: 9/20/96	Lab File Number(s)	: TVB10920028,029
Date Analyzed	: 9/21/96	Method Blank	: MB1092096
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (mg/L)	Sample Concentration (mg/L)	MS Concentration (mg/L)	MS %REC	QC (#) Limits %REC
Gasoline	2.00	0.78	3.00	111.0%	61 - 126
Surrogate **	---	---	---	96%	70 - 121

Compound	Spike Added (mg/L)	MSD Concentration (mg/L)	MSD %REC	RPD	QC (#) Limits RPD	QC (#) Limits %REC
Gasoline	2.00	3.16	119.0%	7.0	27	61 - 126
Surrogate **	---	---	97%	NA	NA	70 - 121

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:
NA = Not analyzed/not applicable.
* = Values outside of QC limits.
** = 1,2,4-Trichlorobenzene
# = Limits established 8/13/96, MAB

Comments: ____________________

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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
TVH Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MP-14	Client Project No	: Westover ARB
Lab Sample No.	: 96-3252-07	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	EPA Method No.	: 5030/8015 Modified
Date Received	: 9/17/96	Matrix	: SOIL
Date Prepared	: 9/20/96	Lab File Number(s)	: TVB10920018,019
Date Analyzed	: 9/20/96	Method Blank	: MB1092096
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (mg/kg)	Sample Concentration (mg/kg)	MS Concentration (mg/kg)	MS %REC	QC (#) Limits %REC
Gasoline	2.00	0.00	1.90	95.0%	50 - 127
Surrogate **	---	---	---	97%	50 - 132

Compound	Spike Added (mg/kg)	MSD Concentration (mg/kg)	MSD %REC	RPD	QC (#) Limits	
					RPD	%REC
Gasoline	2.00	1.84	92.0%	3.2	50	50 - 127
Surrogate **	---	---	96%	NA	NA	50 - 132

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes:
NA = Not analyzed/not applicable.
* = Values outside of QC limits.
** = 1,2,4-Trichlorobenzene
# = Limits established 8/13/96, MAB

Comments:

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EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MP-14	Client Project No.	: Westover ARB
Lab Sample No.	: 96-3252-07	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	EPA Method No.	: 602/8020
Date Received	: 9/17/96	Matrix	: SOIL
Date Prepared	: 9/20/96	Lab File Number(s)	: TVB10920023,024
Date Analyzed	: 9/20/96	Method Blank	: MB1092096
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (ug/kg)	Sample Concentration (ug/kg)	Concentration (ug/kg)		Comments
			MS	MSD	
Benzene	20.0	0.0	19.3	18.8	
Toluene	20.0	0.0	18.6	18.0	
Chlorobenzene	20.0	0.0	19.2	18.8	
Ethylbenzene	20.0	0.0	18.7	18.0	
m,p-Xylene	20.0	0.0	18.0	17.4	
o-Xylene	20.0	0.0	19.4	18.5	
1,3,5-TMB	20.0	0.0	19.3	18.6	
1,2,4-TMB	20.0	0.0	18.8	17.8	
1,2,3-TMB	20.0	0.7	19.0	18.4	
1,2,3,4-TeMB	20.0	0.0	17.5	17.5	
Surrogate	100.0	100%	101%	102%	% RECOVERY

Compound		MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits			
					RPD	%REC		
Benzene		96.5	94.0	2.6	24	47	-	129
Toluene		93.0	90.0	3.3	26	46	-	134
Chlorobenzene		96.0	94.0	2.1	22	57	-	113
Ethylbenzene		93.5	90.0	3.8	28	32	-	136
m,p-Xylene		90.0	87.0	3.4	30	33	-	136
o-Xylene		97.0	92.5	4.7	31	32	-	134
1,3,5-TMB		96.5	93.0	3.7	27	44	-	121
1,2,4-TMB		94.0	89.0	5.5	25	40	-	123
1,2,3-TMB		91.5	88.5	3.3	26	42	-	120
1,2,3,4-TeMB		87.5	87.5	0.0	26	32	-	126
Surrogate		101.0	102.0	NA	NA	72	-	118

#= Limits extablished 8/13/96, MAB.
*= Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments: VALUES BASED ON WET WEIGHT.

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MSBTMB1;MSB3252A.XLS; 9/25/96

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EPA 602/8020 Matrix Spike/Matrix Spike Duplicate Data Report

Client Sample No.	: MP-13	Client Project No.	: Westover ARB
Lab Sample No.	: 96-3252-11	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	EPA Method No.	: 602/8020
Date Received	: 9/17/96	Matrix	: WATER
Date Prepared	: 9/24/96	Lab File Number(s)	: TVB10923030,031
Date Analyzed	: 9/24/96	Method Blank	: MB1092496
Instrument Name	: TVHBTEX1	Dilution Factor	: 1.0

Compound	Spike Added (ug/L)	Sample Concentration (ug/L)	Concentration (ug/L) MS	Concentration (ug/L) MSD	Comments
Benzene	20.0	0.0	18.4	18.7	
Toluene	20.0	0.0	19.1	19.3	
Chlorobenzene	20.0	0.0	19.0	19.0	
Ethylbenzene	20.0	0.0	19.3	19.4	
m,p-Xylene	20.0	0.0	19.9	20.1	
o-Xylene	20.0	0.0	19.3	19.3	
1,3,5-TMB	20.0	0.0	19.3	18.6	
1,2,4-TMB	20.0	0.0	18.9	18.8	
1,2,3-TMB	20.0	0.0	18.8	19.6	
1,2,3,4-TeMB	20.0	0.0	17.7	18.1	
Surrogate	100.0	104%	104%	104%	% RECOVERY

Compound		MS % RECOVERY	MSD % RECOVERY	RPD	QC# Limits RPD	QC# Limits %REC
Benzene		92.0	93.5	1.6	20	59 - 130
Toluene		95.5	96.5	1.0	27	51 - 135
Chlorobenzene		95.0	95.0	0.0	8	60 - 126
Ethylbenzene		96.5	97.0	0.5	15	57 - 127
m,p-Xylene		99.5	100.5	1.0	21	50 - 137
o-Xylene		96.5	96.5	0.0	18	55 - 131
1,3,5-TMB		96.5	93.0	3.7	13	58 - 134
1,2,4-TMB		94.5	94.0	0.5	12	54 - 134
1,2,3-TMB		94.0	98.0	4.2	9	58 - 133
1,2,3,4-TeMB		88.5	90.5	2.2	23	49 - 141
Surrogate		104.0	104.0	NA	NA	82 - 115

#= Limits extablished 8/13/96, MAB.
*= Values outside of QC limits.

RPD: 0 out of (10) outside limits.
Spike Recovery: 0 out of (20) outside limits.

Comments:

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TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: LCS1092196-GAS	Matrix	: WATER
Date Prepared	: 9/21/96	Method Numbers	: EPA 5030/8015 Modified
Date Analyzed	: 9/21/96	Instrument Name	: TVHBTEX1
Lab File Number(s)	: TVB10920034		

Compound Name	Theoretical Concentration (mg/L)	LCS Concentration (mg/L)	LCS % Recovery	QC Limit % Recovery
Gasoline	2.00	2.16	108.0	82 - 120
Surrogate Recovery:		100%		70 - 121

QUALIFIERS

B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA = Not Available/Not Applicable.
** = Limits established 8/13/96 for TVHBTEX1. MAB

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EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number	: LCS1092196-BTEX	Dilution Factor	: 1.00
Date Extracted/Prepared	: 9/21/96	Method	: 602/8020
Date Analyzed	: 9/21/96	Matrix	: Water
Spike Amount (ug/L)	: 20.0	Lab File No.	: TVB10920035

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	18.6	93.0	73 - 107
Toluene	108-88-3	18.3	91.5	74 - 110
Chlorobenzene	108-90-7	17.3	86.5	67 - 106
Ethyl Benzene	100-41-4	18.3	91.5	73 - 112
m,p-Xylene	108-38-3 106-42-3	34.9	87.3	71 - 11[illegible]
o-Xylene	95-47-6	18.1	90.5	72 - 115
MTBE	1634-04-4	16.4	82.0	53 - 131
1,3,5-Trimethylbenzene	108-67-8	16.2	81.0	69 - 96
1,2,4-Trimethylbenzene	95-63-6	17.5	87.5	70 - 100
1,2,3-Trimethylbenzene	526-73-8	21.2	106.0	81 - 119
1,2,3,4-Tetramethylbenzene	488-23-3	18.1	90.5	63 - 116
Surrogate Recovery:		101%		82 - 115

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:
E = Extrapolated value. Value exceeds that of the calibration range.
U = Compound analyzed for, but not detected.
B = Compound found in blank and sample. Compare blank and sample data.
NA =Not available/Not analyzed.
** = Limits updated 8/13/96 for TVHBTEX1. MAB

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EPA 602/8020 Data Report
Laboratory Control Sample (LCS)

LCS Number	: LCS1092396-BTEX	Dilution Factor	:	1.00
Date Extracted/Prepared	: 9/23/96	Method	:	602/8020
Date Analyzed	: 9/23/96	Matrix	:	Water
Spike Amount (ug/L)	: 20.0	Lab File No.	:	TVB10923019

Compound Name	Cas Number	LCS Concentration (ug/L)	LCS % Recovery	QC Limit** % Recovery
Benzene	71-43-2	17.3	86.5	73 - 107
Toluene	108-88-3	17.0	85.0	74 - 110
Chlorobenzene	108-90-7	16.4	82.0	67 - 106
Ethyl Benzene	100-41-4	17.5	87.5	73 - 112
m,p-Xylene	108-38-3 106-42-3	34.2	85.5	71 - 110
o-Xylene	95-47-6	17.9	89.5	72 - 115
MTBE	1634-04-4	18.9	94.5	53 - 131
1,3,5-Trimethylbenzene	108-67-8	16.2	81.0	69 - 96
1,2,4-Trimethylbenzene	95-63-6	16.8	84.0	70 - 100
1,2,3-Trimethylbenzene	526-73-8	20.0	100.0	81 - 119
1,2,3,4-Tetramethylbenzene	488-23-3	17.7	88.5	63 - 116
Surrogate Recovery:		106%		82 - 115

NOTES: m,p-xylene = 40.0 ppb spike.

QUALIFIERS:
E = Extrapolated value. Value exceeds that of the calibration range.
U = Compound analyzed for, but not detected.
B = Compound found in blank and sample. Compare blank and sample data.
NA = Not available/Not analyzed.
** = Limits updated 8/13/96 for TVHBTEX1. MAB

K. Hollman
Analyst

D McClell
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

TOTAL VOLATILE HYDROCARBONS (TVH as Gasoline)
Laboratory Control Sample (LCS)

LCS Number	: LCS1092496-Gas	Matrix	: WATER
Date Prepared	: 9/24/96	Method Numbers	: EPA 5030/8015 Modified
Date Analyzed	: 9/24/96	Instrument Name	: TVHBTEX1
Lab File Number(s)	: TVB10923039		

Compound Name	Theoretical Concentration (mg/L)	LCS Concentration (mg/L)	LCS % Recovery	QC Limit % Recovery
Gasoline	2.00	2.13	106.4	82 - 120
Surrogate Recovery:		100%		70 - 121

QUALIFIERS
B = TVH as Gasoline found in blank also.
E = Extrapolated value. Value exceeds calibration range.
NA = Not Available/Not Applicable.
** = Limits established 8/13/96 for TVHBTEX1. MAB

K. Hollman
Analyst

Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form
Method Blank Report

Method Blank Number	: GB092596	**Client Project No.**	: Westover ARB
Date Extracted/Prepared	: 9/25/96	**Lab Work Order**	: 96-3252
Date Analyzed	: 9/25/96	**Dilution Factor**	: 1.00
		Method	: RSKSOP-175M
		Matrix	: Water
		Lab File No.	: GAS0923043

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Holliman
Approved

AF3252.XLS

EVERGREEN ANALYTICAL, INC.
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Methane Report Form

Client Sample Number	: OBG-7	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-02	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	Dilution Factor	: 1.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923055

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.004	0.002

Temperature	: 74.2 F	Saturation	Meth	0.0008
Amount Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0.00274965
Head space created	: 4 ml	in Head Space		
Methane Area	: 20.378 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Bill Michener
Analyst

K. Hellman
Approved

AF3252.XLS

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Methane Report Form

Client Sample Number	: MW-114	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-03	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	Dilution Factor	: 1.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923056

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.004	0.002

Temperature	: 74.2 F	Saturation Concentration	Meth	0.000850631
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.0026691
Head space created	: 4 ml			
Methane Area	: 19.781 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Analyst

K. Hollman
Approved

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4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: ECS-22	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-04	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	Dilution Factor	: 1.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923057

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 74.2 F	Saturation Concentration	Meth	(
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	(
Head space created	: 4 ml			
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3252.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Methane Report Form

Client Sample Number	: MW-115	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-05	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	Dilution Factor	: 1.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923060

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	: 74.4 F	Saturation	Meth	0
Amount Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0
Head space created	: 4 ml	in Head Space		
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hellman
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Methane Report Form

Client Sample Number	: MW-115	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-05Dup	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	Dilution Factor	: 1.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923061

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

Temperature	:	74.5 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	0 ug

Saturation Concentration	Meth	
Concentration in Head Space	Meth	

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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EVERGREEN ANALYTICAL, INC.
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Methane Report Form

Client Sample Number	: MP-11S	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-08	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Dilution Factor	: 20.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923062

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	1.69	0.04

mperature	:	74.5 F
Amount Injected	:	0.025 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	474.394 ug

Saturation Concentration	Meth	0.408001813
Concentration in Head Space	Meth	1.279504327

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: MP-11D	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-09	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Dilution Factor	: 20.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923063

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.79	0.04

Temperature	:	74.5 F
Amount Injected	:	0.025 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	222.444 ug
Atomic weight(Methane)	:	16 g

Saturation Concentration	Meth	0.1913[illegible]1
Concentration in Head Space	Meth	0.59996134

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA =Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: MP-12	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-10	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Dilution Factor	: 1.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923064

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.143	0.002

Temperature	:	74.6 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	803.237 ug

Saturation Concentration	Meth	0.034541136
Concentration in Head Space	Meth	0.108301618

Atomic weight(Methane) : 16 g

Qualifiers

E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: MP-13	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-11	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Dilution Factor	: 1.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923066

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.009	0.002

Temperature	: 74.5 F	Saturation Concentration	Meth	0.0022
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.00693473
Head space created	: 4 ml			
Methane Area	: 51.423 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

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Methane Report Form

Client Sample Number	: OBG-8	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-12	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Dilution Factor	: 1.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923067

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.007	0.002

nperature	: 74.6 F	Saturation Concentration	Meth	0.001664237
Amount Injected	: 0.5 ml			
Total Volume of Sample	: 43 ml	Concentration in Head Space	Meth	0.005218112
Head space created	: 4 ml			
Methane Area	: 38.701 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3252.XLS

EVERGREEN ANALYTICAL, INC.
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Methane Report Form

Client Sample Number	: OBG-10	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-13	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Dilution Factor	: 1.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923068

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.004	0.002

Temperature	:	74.5 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	20.088 ug

Saturation Concentration	Meth	0.0008[illegible]3
Concentration in Head Space	Meth	0.00270900

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3252.XLS

EVERGREEN ANALYTICAL, INC.
4036 Youngfield St. Wheat Ridge, CO 80033
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Methane Report Form

Client Sample Number	: MP-14(S)	Client Project No.	: Westover ARB
Lab Sample Number	: 96-3252-15	Lab Work Order	: 96-3252
Date Sampled	: 9/15/96	Dilution Factor	: 1.00
Date Received	: 9/17/96	Method	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Lab File No.	: GAS0923069

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	U	0.002

●nperature	: 74.4 F	Saturation	Meth	0
Amount Injected	: 0.5 ml	Concentration		
Total Volume of Sample	: 43 ml	Concentration	Meth	0
Head space created	: 4 ml	in Head Space		
Methane Area	: 0 ug			

Atomic weight(Methane) : 16 g

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Bill Michener
Analyst

K. Hollman
Approved

AF3252.XLS

EVERGREEN ANALYTICAL, INC.
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Methane Report Form

Client Sample Number	: MP-14(D)	**Client Project No.**	: Westover ARB
Lab Sample Number	: 96-3252-16	**Lab Work Order**	: 96-3252
Date Sampled	: 9/15/96	**Dilution Factor**	: 1.00
Date Received	: 9/17/96	**Method**	: RSKSOP-175M
Date Extracted/Prepared	: 9/25/96	**Matrix**	: Water
Date Analyzed	: 9/25/96	**Lab File No.**	: GAS0923070

Compound Name	Cas Number	Sample Concentration mg/L	RL mg/L
Methane	74-82-8	0.003	0.002

Temperature	:	74.4 F
Amount Injected	:	0.5 ml
Total Volume of Sample	:	43 ml
Head space created	:	4 ml
Methane Area	:	17.229 ug
Atomic weight(Methane)	:	16 g

Saturation Concentration	Meth	0.0007[illegible]8
Concentration in Head Space	Meth	0.00232388

Qualifiers
E = Extrapolated value.
U = Compound analyzed for, but not detected.
B = Compound also found in the blank.
RL = Reporting Limit.
NA = Not Available/Not Applicable.

Analyst

K. Hollman
Approved

AF3252.XLS

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane Gas Matrix Spike / Matrix Spike Duplicate Report

Client Sample No.	: ECS-22	Client Project No.	: Westover ARB
Lab Sample No.	: 96-3252-04	Lab Work Order	: 96-3252
Date Sampled	: 9/14/96	EPA Method No.	: RSKSOP-175M
Date Received	: 9/17/96	Matrix	: Water
Date Prepared	: 9/25/96	Method Blank	: GB092596
Date Analyzed	: 9/25/96	Lab File No's.	: GAS0923058
E.A. MS/MSD Spike Source No.	: 1886		

Compound	Spike Added (ug)	Sample Concentration (ug)	MS Concentration (ug)	MS %REC	QC Limits %REC
Methane Gas	500	0	410	82	40-89

Compound	Spike Added (ug)	MSD Concentration (ug)	MSD %REC	RPD	QC Limits RPD	QC Limits %REC
Methane Gas	500	404	81	1.6	0-24.4	40-89

RPD: 0 out of (1) outside limits.
Spike Recovery: 0 out of (2) outside limits.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available

Note: The Spike was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Analyst

K. Hollman
Approved

MS3252.XLS; 9/25/96

Evergreen Analytical, Inc.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

RSKSOP-175M Gas Method
Methane LCS Report Form

LCS No.	: LCS092596	EPA Method No.	: RSKSOP-175M
Date Prepared	: 9/25/96	Matrix	: Water
Date Analyzed	: 9/25/96	Method Blank	: GB092596
E.A. LCS Source No.	: 1886	Lab File No.	: GAS0923035

Compound	Spike Added (ug)	Method Blank Concentration (ug)	LCS Concentration (ug)	LCS %REC	QC Limits %REC
Methane Gas	500	0	412	82	67-85

Spike Recovery: 0 out of (1) outside limits.

Note: The LCS was made by taking the sample and displacing 4ml of headspace with a 1% methane gas and shaking the VOA for 5 minutes. Then injecting 50 ul from the headspace into the GC resulting in a theoretical concentration of 500 ug.

Notes
* = Values outside of QC limits.
NA = Not analyzed/not available.

Analyst

K. Hellman
Approved

EVERGREEN ANALYTICAL, INC.
4036 Youngfield, Wheat Ridge, CO 80033
(303) 425-6021

Method 8010 Chlorinated VOC's Method Blank Report

Method Blank	:	RB092696	Client Project No.	:	729691.28010 Westover ARB
Date Prepared	:	09/26/96	Lab Project No.	:	96-3252
Date Analyzed	:	09/26/96	Lab File No.	:	HALL0926\021F0101

Compound	CAS #	Concentration (ug/L)	RL(ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	U	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 92% 70% - 130% (QC limits)

QUALIFIERS:

U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW3252.XLS; 10/3/96

EVERGREEN ANALYTICAL, INC.
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Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	:	MP-11S	Client Project No.	:	729691.28010 Westover ARB
Lab Sample No.	:	96-3252-08	Lab Project No.	:	96-3252
Date Sampled	:	09/15/96	Matrix	:	Water
Date Received	:	09/17/96	Lab File No.	:	HALL0926\036F0101
Date Prepared	:	09/26/96	Method Blank	:	RB092696
Date Analyzed	:	09/27/96	Dilution Factor	:	1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	2.3	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	U	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0[illegible]
4-Chlorotoluene	106-49-8	U	0[illegible]
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 89% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

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HLW3252.XLS; 10/3/96

EVERGREEN ANALYTICAL, INC.
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Method 601/8010 Chlorinated VOC's Sample Report

Client Sample No.	: MP-11D	Client Project No.	: 729691.28010 Westover ARB
Lab Sample No.	: 96-3252-09	Lab Project No.	: 96-3252
Date Sampled	: 09/15/96	Matrix	: Water
Date Received	: 09/17/96	Lab File No.	: HALL0926\037F0101
Date Prepared	: 09/26/96	Method Blank	: RB092696
Date Analyzed	: 09/27/96	Dilution Factor	: 1.0

Compound	CAS #	Concentration (ug/L)	RL (ug/L)
Vinyl Chloride	75-01-4	U	0.4
Chloroethane	75-00-3	U	0.4
1,1-Dichloroethene	75-35-4	U	0.4
Dichloromethane	75-09-2	U	0.4
trans-1,2-Dichloroethene	156-60-5	U	0.4
1,1-Dichloroethane	75-34-3	U	0.4
cis-1,2-Dichloroethene	156-59-4	9.2	0.4
1,1,1-Trichloroethane	71-55-6	U	0.4
Carbon Tetrachloride	56-23-5	U	0.4
Trichloroethene	79-01-6	28	0.4
1,1,2-Trichloroethane	79-00-5	U	0.4
Tetrachloroethene	127-18-4	U	0.4
1,1,1,2-Tetrachloroethane	79-00-5	U	0.4
Chlorobenzene	108-90-7	U	0.42
1,1,2,2-Tetrachloroethane	79-34-5	U	0.54
2-Chlorotoluene	95-49-8	U	0.4
4-Chlorotoluene	106-49-8	U	0.4
1,3-Dichlorobenzene	541-73-1	U	0.4
1,2-Dichlorobenzene	95-50-1	U	0.4

Surrogate Recovery (1-Chloro-2-Fluoro-Benzene) : 84% 70% - 130% (QC limits)

QUALIFIERS:
U = Compound analyzed for, but not detected above the Reporting Limit.
B = Compound in blank and sample. Compare blank and sample data.
E = Extrapolated value. Concentration exceeds the upper limit of the calibration.
RL = Reporting Limit (at or above method detection limit).

NOTES:

Analyst

Approved

HLW3252.XLS; 10/3/96

EVERGREEN ANALYTICAL, Inc.
4036 Youngfield St. Wheat Ridge, CO 80033
(303) 425-6021

Anion Report

Date Sampled	: 9/14/96				Westover ARB
			Client Project ID.	:	729691.28010
Date Received	: 9/17/96		Lab Project Number	:	96-3252
Date Prepared	: 9/17/96		Method	:	EPA 300.0
Date Analyzed	: 9/17/96		Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride mg/L	Dilution Factor
96-3252-02	OBG-7	Water	37.7	10
96-3252-03	MW-114	Water	41.9	10
96-3252-04	ECS-22	Water	18.2	1
96-3252-04 Duplicate	ECS-22 Duplicate	Water	17.9	1
96-3252-05	MW-115	Water	18.0	1
Method Blank	(9/17/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3252-04	ECS-22 Matrix Spike	10.0	18.2	28.2	100
96-3252-04	ECS-22 Matrix Spike Dup	10.0	18.2	28.1	98
MS/MSD RPD					1.2

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Anion Report

					Westover ARB
Date Sampled	:	9/15/96	Client Project ID.	:	729691.28010
Date Received	:	9/17/96	Lab Project Number	:	96-3252
Date Prepared	:	9/17/96	Method	:	EPA 300.0
Date Analyzed	:	9/17/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Chloride mg/L	Dilution Factor
96-3252-08	MP-11S	Water	5.5	1
96-3252-09	MP-11D	Water	8.0	1
96-3252-10	MP-12	Water	37.5	1
96-3252-11	MP-13	Water	31.2	1
96-3252-12	OBG-8	Water	57.6	10
96-3252-13	OBG-10	Water	40.0	10
96-3252-15	MP-14(S)	Water	12.2	1
96-3252-16	MP-14(D)	Water	12.5	1

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(303) 425-6021

Anion Report

Date Sampled	: 9/14/96		Client Project ID.	:	Westover ARB 729691.28010
Date Received	: 9/17/96		Lab Project Number	:	96-3252
Date Prepared	: 9/17/96		Method	:	EPA 300.0
Date Analyzed	: 9/17/96		Detection Limit	:	0.076 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N mg/L	Dilution Factor
96-3252-02	OBG-7	Water	**	1
96-3252-03	MW-114	Water	**	1
96-3252-04	ECS-22	Water	**	1
96-3252-04 Duplicate	ECS-22 Duplicate	Water	**	1
96-3252-05	MW-115	Water	**	1
Method Blank	(9/17/96)		<0.076	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3252-04	ECS-22 Matrix Spike	10.0	<0.25	9.2	92
96-3252-04	ECS-22 Matrix Spike Dup	10.0	<0.25	8.9	89
MS/MSD RPD					3.2

* = Quality assurance results reported as Nitrite (NO_2).

** = Samples received outside of holding time, see nitrate report.

Analyst

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(303) 425-6021

Anion Report

					Westover ARB
Date Sampled	:	9/15/96	Client Project ID.	:	729691.28010
Date Received	:	9/17/96	Lab Project Number	:	96-3252
Date Prepared	:	9/17/96	Method	:	EPA 300.0
Date Analyzed	:	9/17/96	Detection Limit	:	0.076 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite-N mg/L	Dilution Factor
96-3252-08	MP-11S	Water	<0.076	1
96-3252-09	MP-11D	Water	<0.076	1
96-3252-10	MP-12	Water	<0.076	1
96-3252-11	MP-13	Water	<0.076	1
96-3252-12	OBG-8	Water	<0.076	1
96-3252-13	OBG-10	Water	<0.076	1
96-3252-15	MP-14(S)	Water	<0.076	1
96-3252-16	MP-14(D)	Water	<0.076	1

Jeff Hale
Analyst

Approved

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Anion Report

Date Sampled	:	9/14/96	Client Project ID.	:	Westover ARB 729691.28010
Date Received	:	9/17/96	Lab Project Number	:	96-3252
Date Prepared	:	9/17/96	Method	:	EPA 300.0
Date Analyzed	:	9/17/96	Detection Limit	:	0.076mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrite + Nitrate-N mg/L	Dilution Factor
96-3252-02	OBG-7	Water	1.6	1
96-3252-03	MW-114	Water	1.6	1
96-3252-04	ECS-22	Water	3.1	1
96-3252-04 Duplicate	ECS-22 Duplicate	Water	3.2	1
96-3252-05	MW-115	Water	2.9	1
Method Blank	(9/17/96)		<0.076	

Quality Assurance *

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3252-04	ECS-22 Matrix Spike	10.0	13.9	24.0	101
96-3252-04	ECS-22 Matrix Spike Dup	10.0	13.9	23.6	97
MS/MSD RPD					4.0

* = Quality assurance results reported as Nitrate (NO_3).

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Anion Report

Date Sampled	: 9/15/96		Client Project ID.	:	Westover ARB 729691.28010
Date Received	: 9/17/96		Lab Project Number	:	96-3252
Date Prepared	: 9/17/96		Method	:	EPA 300.0
Date Analyzed	: 9/17/96		Detection Limit	:	0.056 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Nitrate-N mg/L	Dilution Factor
96-3252-08	MP-11S	Water	0.14	1
96-3252-09	MP-11D	Water	<0.056	1
96-3252-10	MP-12	Water	<0.056	1
96-3252-11	MP-13	Water	1.3	1
96-3252-12	OBG-8	Water	0.52	1
96-3252-13	OBG-10	Water	2.5	1
96-3252-15	MP-14(S)	Water	0.26	1
96-3252-16	MP-14(D)	Water	0.067	1

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Anion Report

Date Sampled	:	9/14/96	Client Project ID.	:	Westover ARB 729691.28010
Date Received	:	9/17/96	Lab Project Number	:	96-3252
Date Prepared	:	9/17/96	Method	:	EPA 300.0
Date Analyzed	:	9/17/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Sulfate mg/L	Dilution Factor
96-3252-02	OBG-7	Water	4.5	1
96-3252-03	MW-114	Water	4.5	1
96-3252-04	ECS-22	Water	10.5	1
96-3252-04 Duplicate	ECS-22 Duplicate	Water	10.5	1
96-3252-05	MW-115	Water	10.2	1
				1
Method Blank	(9/17/96)		<0.25	

Quality Assurance

		Spike Amount (mg/L)	Sample Result (mg/L)	Spike Result (mg/L)	% Recovery
96-3252-04	ECS-22 Matrix Spike	10.0	12.5	22.8	103
96-3252-04	ECS-22 Matrix Spike Dup	10.0	12.5	22.6	100
MS/MSD RPD					2.3

Analyst

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Anion Report

Date Sampled	: 9/15/96	Client Project ID.	:	Westover ARB 729691.28010
Date Received	: 9/17/96	Lab Project Number	:	96-3252
Date Prepared	: 9/17/96	Method	:	EPA 300.0
Date Analyzed	: 9/17/96	Detection Limit	:	0.25 mg/L

Evergreen Sample #	Client Sample ID.	Matrix	Sulfate mg/L	Dilution Factor
96-3252-08	MP-11S	Water	3.3	1
96-3252-09	MP-11D	Water	7.3	1
96-3252-10	MP-12	Water	27.6	1
96-3252-11	MP-13	Water	34.7	1
96-3252-12	OBG-8	Water	4.7	1
96-3252-13	OBG-10	Water	10.9	1
96-3252-15	MP-14(S)	Water	4.8	1
96-3252-16	MP-14(D)	Water	12.8	1

Analyst

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(303) 425-6021

Analysis Report

Date Sampled	: 9/15/96	Client Project ID.	: 729691.28010
Date Received	: 9/17/96	Lab Project Number	: 96-3252
Date Prepared	: 9/27/96	Method	: EPA 310.1
Date Analyzed	: 9/27/96	Detection Limit	: 5.0 mg $CaCO_3$/L

Evergreen Sample #	Client Sample ID.	Matrix	Total Alkalinity (mg $CaCO_3$/L)	Dilution Factor
96-3252-13	OBG-10	Water	32.3	1
96-3252-13 Dup	OBG-10 Dup	Water	36.3	1
Method Blank	(9/27/96)		<5.0	

Quality Assurance

Reference	True Value (mg$CaCO_3$/L)	Result (mg$CaCO_3$/L)	% Recovery
ERA Minerals Lot# 9970	180	194	108

Analyst

Approved

SEP 2 4 1996

CUSTOMER #:
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DATE 9/23/96
LAB# 206796
P.O. 13380
RECD 09/19/96

ANALYSIS REPORT

PATTY MC CLELLEN
EVERGREEN ANALYTICAL, INC
4036 YOUNGFIELD STREET
WHEAT RIDGE CO 80033

SEQUENCE/ SAMPLE NUMBER	ANALYSIS CARBONATE C---%	TOTAL CARBON--%	ORGANIC C-----%	EAL Sample#	% moisture	Dry weight basis
01/MP-1-	<0.02-	<0.05-	<0.05	-3151-05	17.57	<0.06
02/MP-3-	<0.02-	<0.05-	<0.05	-3185-04	3.24	<0.05
03/MP-4-	<0.02-	<0.05-	<0.05	-3185-05	17.30	<0.06
04/SS-1-	<0.02-	<0.05-	<0.05	-3185-10	5.04	<0.05
05/MP-6-	<0.02-	<0.05-	<0.05	-3185-12	5.15	<0.05
06/MP-2-	<0.02-	0.50-	0.50	-3185-13	10.24	0.55
07/MP-10-	<0.02	<0.05	<0.05	-3235-13	6.62	<0.05
08/MP-11-	<0.02	<0.05	<0.05	-3252-06	15.32	<0.06
09/MP-14-	<0.02	<0.05	<0.05	-3252-07	10.84	<0.06
10/SS-2-	<0.02-	0.18-	0.18	-3252-17	9.54	0.20
11/SS-3-	<0.02-	<0.05-	<0.05	3252-18	4.06	<0.05
12/SS-4-	<0.02-	0.21-	0.21	-3252-19	9.49	0.23
13/SS-5 (12')-	<0.02-	<0.05-	<0.05	-3252-22	6.30	<0.05

APPENDIX C

BIODEGRADATION RATE CALCULATIONS AND OTHER CALCULATIONS

In press: Proceedings of the Battelle In Situ and On-Site Bioreclamation Symposium, April 24-27, 1995, San Diego, CA.

REGRESSION TECHNIQUES AND ANALYTICAL SOLUTIONS TO DEMONSTRATE INTRINSIC BIOREMEDIATION

Timothy E. Buscheck and Celia M. Alcantar
Chevron Research and Technology Company
Richmond, CA

ABSTRACT

It is now generally recognized that a major factor responsible for the attenuation and mass reduction of benzene, toluene, ethylbenzene, and xylenes (BTEX) in groundwater plumes is hydrocarbon biodegradation by indigenous microorganisms in aquifer material. Our objective is to apply well-known regression techniques and analytical solutions to estimate the contribution of advection, dispersion, sorption, and biodecay to the overall attenuation of petroleum hydrocarbons. These calculations yield an apparent biodecay rate based on field data. This biodecay rate is a significant portion of the overall attenuation in stable, dissolved hydrocarbon plumes.

INTRODUCTION

"Intrinsic bioremediation" is the degradation of organic compounds by indigenous microbes without artificial enhancement. Advection, dispersion, sorption, and decay each contribute to the overall attenuation of a dissolved hydrocarbon plume. The effect of advection is to transport dissolved contaminants at the same rate as the groundwater velocity. The effect of dispersion is to spread contaminant mass beyond the volume it would occupy due to advection alone, and reduce contaminant concentrations. The effect of sorption is to retard contaminant migration. These factors affect the configuration of dissolved hydrocarbon plumes. Overall attenuation can cause a plume to shrink over time, create a stable plume, or reduce the rate of plume migration. Two of the conditions for which intrinsic bioremediation is likely to contribute to the configuration of a contaminant plume are a shrinking plume and a stable plume. The configuration of a migrating plume can also be affected by intrinsic bioremediation. Under the conditions of a shrinking plume, degradation mechanisms are necessarily present. Intrinsic bioremediation also is likely to contribute to a stable plume, particularly if the source persists in residually contaminated soils at the water table. In this paper we couple the regression of concentration versus distance for stable plumes to an analytical solution for one-dimensional, steady-state, contaminant transport. The analytical solution includes advection, dispersion, sorption, and decay.

Biological transformation is the process that likely contributes most to the decay of compounds such as BTEX. Several studies suggest the concurrent loss of electron acceptors from groundwater as an indicator of biodegradation (McAllister and Chiang 1994, Salanitro 1993). The mechanism of biodegradation is complex, and the rate is most likely controlled by the mixing of the contaminant and electron acceptors in a three-dimensional, heterogeneous aquifer. The assumption of a first-order decay is a useful approximation of this complex phenomenon. Evaluation of site data suggests apparent first-order attenuation rates occur in the range of 0.1 to 1.0 % per day (Buscheck et al. 1993).

The objective of this paper is to provide tools to assist in documenting the loss of contaminants. The regression techniques and analytical solution described are intended to distinguish those mechanisms that contribute to contaminant loss.

PLUME CHARACTERISTICS

Shrinking Plume

Dissolved hydrocarbon plumes may decrease in size, as observed by declining contaminant concentrations in monitoring wells. Exponential regression methods can be used to evaluate whether concentration versus time data fit a first-order decay observed for petroleum hydrocarbons under certain conditions. The solution to the first-order decay is:

$$C(t) = C_i e^{-(kt)} \tag{1}$$

Where C(t) (M/L^3) is concentration as a function of time, t (T), C_i is the initial concentration at t = 0, and k is the first-order attenuation rate, T^{-1}. Equation (1) may be used to evaluate contaminant concentration versus time data for individual monitoring wells.

Stable Plume

A stable plume is characterized by dissolved contaminant concentrations remaining constant over time in individual monitoring wells. Short-term variations in monitoring well concentrations due to water table fluctuation, variability in groundwater flow direction, sampling variability, and analytical uncertainty should be distinguished from statistically significant concentration changes. In order for a plume to reach stable conditions, the rate of natural attenuation must be equal to the rate of contaminant addition to the aquifer from the source (McAllister and Chiang 1994). The contaminant source or influx rate is limited by the compound's effective solubility and the flow rate of water through the source area (infiltration, fluctuating water table, etc.).

Kemblowski et al. (1987) recast equation (1) for concentration as a function of distance:

$$C(x) = C_o e^{-(k\frac{x}{v_x})} \tag{2}$$

Where C_o (M/L^3) is the concentration at the source. The transformation of the exponential terms in equations (1) and (2) is achieved by substituting time, t, with distance traveled, x (L) divided by the linear groundwater velocity, v_x (L/T). The term "x/v_x" is the residence time for pore water to move some distance, x, from the source. The concentration versus distance regression is based on equation (2). The groundwater flow direction is defined based on multiple monitoring events covering the hydrologic cycle. Six monitoring wells were selected along the groundwater flow path (see inset of Figure 1). A minimum of three monitoring wells are required for this analysis. In this case, contaminant concentrations declined with downgradient distance. Figure 1 plots benzene concentration versus distance for a terminal in Fairfax, Virginia. From the exponent of equation (2), the slope of the line in Figure 1 is k/v_x (L^{-1}), the reciprocal of the attenuation distance. If this slope is multiplied by groundwater velocity (L/T), we obtain

k (T^{-1}). In the absence of a reliable estimate of groundwater velocity, the k/v_x term is useful, particularly for estimating the downgradient extent of contaminant migration and selecting downgradient monitoring well locations.

ANALYTICAL SOLUTION FOR A STABLE PLUME

The general one-dimensional transport equation, with first-order decay of the contaminant, is given by the following equation:

$$\frac{\delta C}{\delta t} = \frac{1}{R_f} [D_x \frac{\delta^2 C}{\delta x^2} - v_x \frac{\delta C}{\delta x}] - \lambda C \tag{3}$$

Where D_x (L^2/T) is the dispersion coefficient, v_x (L/T) is the linear groundwater velocity, R_f (-) is the retardation coefficient, and λ (T^{-1}) is the total decay rate. The form of equation (3) assumes D_x is constant and independent of distance, x. While the terms in brackets describe the mass transport by dispersion and advection, respectively, the retardation coefficient characterizes the contribution of sorption. The form of this equation assumes degradation occurs in the aqueous and sorbed phases at the same rate. If biological transformation of BTEX compounds occurs primarily in the aqueous phase, the term "λC" would appear inside the brackets.

Dispersion and advection are related by the longitudinal dispersivity, α_x (L), which has been described by empirical expressions (Fetter 1993).

$$D_x = \alpha_x v_x \tag{4}$$

The retardation coefficient (R_f) accounts for contaminant partitioning between the solid and aqueous phases. R_f describes the relationship between the linear groundwater velocity, and contaminant velocity, v_c (L/T):

$$R_f = \frac{v_x}{v_c} \tag{5}$$

Chiang et al. (1989) demonstrated that the contribution of volatilization to the dissolved contaminant attenuation was only 5% at one site. Except in the case of very shallow groundwater, volatilization is not expected to contribute significantly to the overall attenuation. Therefore, volatilization is neglected and the decay rate is assumed to be a measure of biodegradation of BTEX compounds.

Bear (1979) solved equation (3) for concentration. The steady-state solution is given as:

$$C(x) = C_o \exp [(\frac{x}{2\alpha_x}) [1 - (1 + \frac{4\lambda\alpha_x}{v_c})^{\frac{1}{2}}]] \tag{6}$$

For the case in which decay occurs only in the aqueous phase, the contaminant velocity, v_c, is replaced by the linear groundwater velocity, v_x, in equation (6). As the decay rate (λ) increases with respect to the other transport mechanisms, the concentration away from the source (x > 0), approaches zero because the material is decaying at a greater rate than it is being transported through the medium. Similarly, as the contaminant velocity increases, the decay becomes less effective in reducing concentrations as a function

of distance. Retarded contaminants therefore have a greater opportunity to decay because retarded transport velocities favor biodegradation kinetics over transport (Domenico and Schwartz 1990).

The exponential regression for concentration versus distance yields the reciprocal of the attenuation distance, k/v_x (L^{-1}), previously shown in equation (2). Equations (2) and (6) are of the same form:

$$C(x) = C_o \exp(mx) \tag{7}$$

The slope of the log-linear data is given by m. The one-dimensional, steady-state transport solution also describes the slope, m, of the log-linear data:

$$m = \left(\frac{1}{2\alpha_x}\right) \left[1-\left(1+\frac{4\lambda\alpha_x}{v_c}\right)^{\frac{1}{2}}\right] \tag{8}$$

Therefore, the term k/v_x and equation (8) both describe the slope of the log-linear data and can be equated to solve for the total decay rate, λ, a measure of intrinsic bioremediation. Dispersivity (α), contaminant velocity (v_c), and k/v_x are input to the following equation to calculate the decay rate.

$$\lambda = \left(\frac{v_c}{4\alpha_x}\right) \left(\left[1+2\alpha_x\left(\frac{k}{v_x}\right)\right]^2 - 1\right) \tag{9}$$

For the case in which decay occurs only in the aqueous phase, v_c is replaced by v_x in equation (9).

RESULTS

The results of equating the spatial regression with the steady-state analytical solution for the Fairfax Terminal are presented in Table 1. The values for source concentration (C_o) and k/v_x were regressed using the data plotted in Figure 1. Table 1 includes k and the ratio, λ/k, the contribution of biodecay to the overall attenuation rate (expressed as %). In Case 1, groundwater velocity was 0.06 m/day, based on aquifer pump tests. Retardation was estimated as 2 and dispersivity was estimated as 7.5 m, approximately 5% of the flow field (distance separating the two furthest wells). In Case 1, λ = 0.30%/day (0.0030 $days^{-1}$); λ is 75% of k for this case. The next four cases were performed to evaluate the sensitivity of changing various input parameters. In each of these cases C_o and k/v_x remain constant. In Case 2, the groundwater velocity is reduced by a factor of two (v = 0.03 m/day), which reduces the decay rate by the same factor (λ = 0.15%/day). In this case, only half the decay rate is required to maintain the Case 1 concentration decline with distance; as in Case 1, λ is 75% of k in Case 2. In Case 3, the dispersivity is increased by a factor of two (α = 15 m) and λ = 0.40%/day. More decay is required with a larger dispersivity because more spreading of the contaminant occurs in the direction of groundwater flow; λ is equivalent to k in Case 3.

Cases 4 and 5 were performed to calculate λ assuming biodecay occurs only in the aqueous phase. This is accomplished by replacing v_c with v_x in equation (9) for λ (R = 1 in Table 1 for Cases 4 and 5). Given this revised formulation, the decay rate, λ, is independent of retardation. By limiting decay to the aqueous phase in Case 4, λ = 0.60%/day, twice the decay rate in Case 1. In Case 4, λ is 150% of k. Case 5 is similar to Case 4, but dispersivity is reduced to 0.3 m. In Case 5, λ = 0.40%/day. Less decay is required with a smaller dispersivity because less spreading of the contaminant plume occurs in the

direction of groundwater flow; λ and k are identical in Case 5.

SUMMARY

Contaminant decay is the primary process contributing to a stable configuration of a dissolved contaminant plume. Given a constant source, sorption and dispersion alone are not likely to account for a stable plume. Sorption only retards contaminant velocity, whereas dispersion results in further spreading of the contaminant, reducing concentrations. Decay (biodegradation of BTEX compounds) is the most significant mechanism that accounts for mass loss in a dissolved contaminant plume. The analytical solution for steady-state contaminant transport can be equated to a regression of concentration versus distance (expressed as k/v_x) to solve for the decay rate, λ. The decay rate is a measure of intrinsic bioremediation of petroleum hydrocarbons and can be used in more sophisticated models.

REFERENCES

Bear, J. 1979. Hydraulics of Groundwater. McGraw-Hill, New York, NY.

Buscheck, T. E., K. T. O'Reilly, and S. N. Nelson. 1993. "Evaluation of Intrinsic Bioremediation at Field Sites." Proceedings, Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Restoration, pp. 367-381. National Ground Water Association/API, Houston, TX.

Chiang, C. Y., J. P. Salanitro, E. Y. Chai, J. D. Colthart, and C. L. Klein. 1989. "Aerobic Biodegradation of Benzene, Toluene, and Xylene in a Sandy Aquifer - Data Analysis and Computer Modeling." Ground Water 27(6): 823-834.

Domenico, P. A. and F. W. Schwartz. 1990. Physical and Chemical Hydrogeology. John Wiley & Sons, New York, NY.

Fetter, C. W. 1993. Contaminant Hydrogeology. Macmillan Publishing Company, New York, NY.

Kemblowski, M. W., J. P. Salanitro, G. M. Deeley, and C. C. Stanley. 1987. "Fate and Transport of Residual Hydrocarbon in Groundwater - A Case Study." Proceedings, Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Restoration, pp. 207-231. National Water Well Association/API, Houston, TX.

McAllister, P. M. and C. Y. Chiang. 1994. "A Practical Approach to Evaluating Natural Attenuation of Contaminants in Ground Water." Ground Water Monitoring and Remediation 14(2): 161-173.

Salanitro, J. P. 1993. "The Role of Bioattenuation in the Management of Aromatic Hydrocarbon Plumes in Aquifers." Ground Water Monitoring and Remediation 13(4): 150-161.

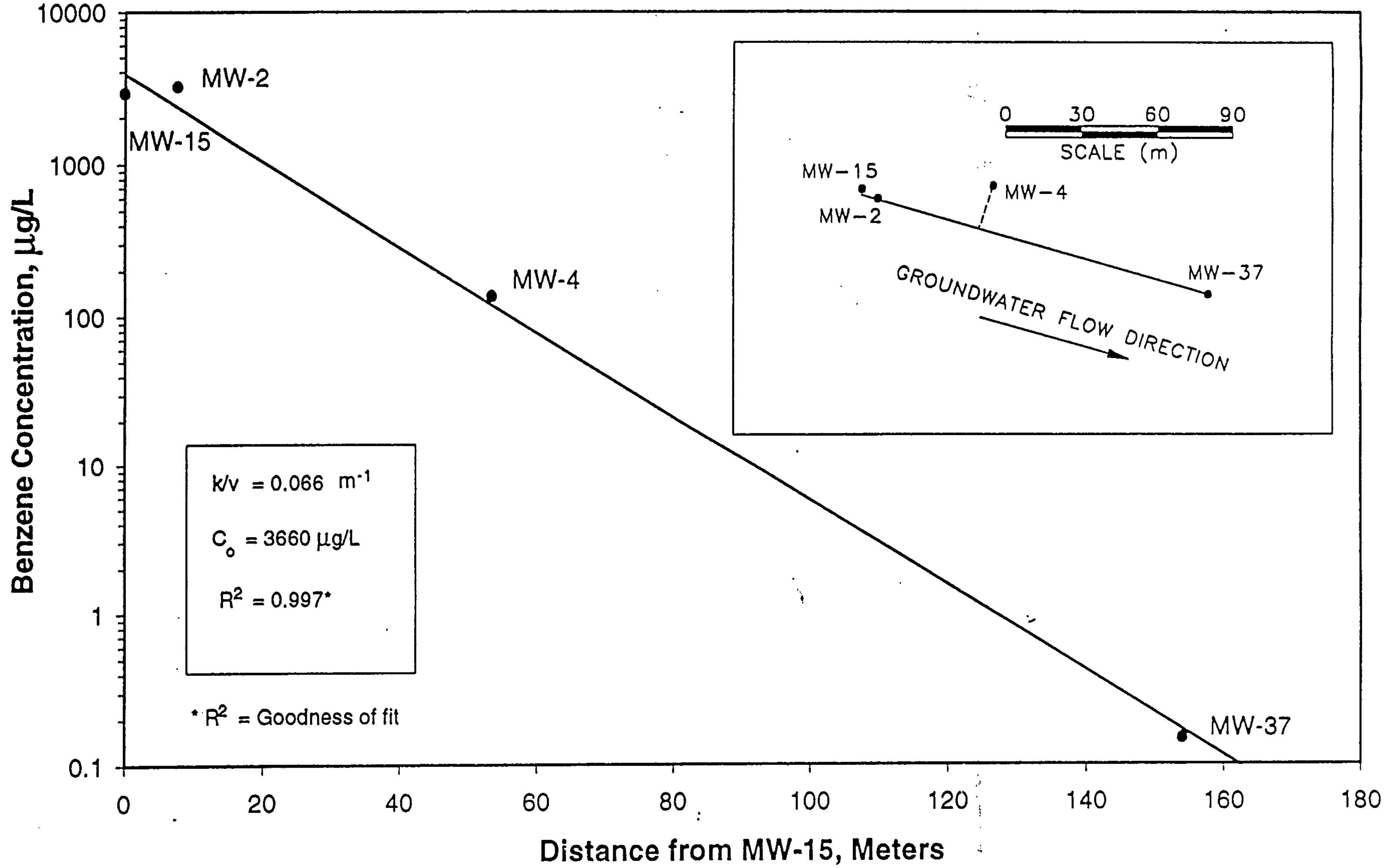

FIGURE 1. Exponential regression of concentration versus distance for Fairfax Terminal.

TABLE 1. Decay rates based on steady-state analytical solution, C_o = 3,660 μg/L, k/v_x = 0.066 m^{-1}. (sensitivity on bold input values)

Case	groundwater velocity, v_x (m/day)	retardation coefficient, R_f	contaminant velocity, v_c (m/day)	dispersivity, α (m)	attenuation rate, k (%/day)	decay rate, λ (%/day)	λ/k (%)
Case 1	0.06	2	0.03	7.5	0.40	0.30	75
Case 2	**0.03**	2	0.015	7.5	0.20	0.15	75
Case 3	0.06	2	0.03	**15**	0.40	0.40	100
Case 4	0.06	**1**(1)	0.06	7.5	0.40	0.60	150
Case 5	0.06	**1**(1)	0.06	**0.3**	0.40	0.40	100

Note: (1) Calculation of λ independent of v_c.

MEAN ERROR, MEAN AVERAGE ERROR, AND ROOT-MEAN-SQUARE ERROR FOR THE CALIBRATED FLOW MODEL

ZONE 1

REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Location	Actual Water Level (h_m)[a/]	Calibrated Water Level (h_s)[a/]	h_m-h_s	abs(h_m-h_s)	$(h_m-h_s)^2$
MW-8	222.1	222.6	0.47	0.47	0.22
MW-11	221.3	221.8	0.46	0.46	0.21
MW-13	225.1	224.1	-0.98	0.98	0.96
MW-14	226.0	224.9	-1.07	1.07	1.14
MW-16	223.6	225.1	1.48	1.48	2.19
MW-19	227.4	226.8	-0.58	0.58	0.34
MW-36	223.3	222.2	-1.10	1.10	1.21
MW-37	221.7	221.0	-0.67	0.67	0.45
MW-39	217.8	218.8	0.99	0.99	0.98
ECS-23	221.4	222.1	0.68	0.68	0.46
ECS-24	222.0	222.6	0.59	0.59	0.35
ECS-26	221.3	222.2	0.86	0.86	0.74
ECS-27	220.5	221.1	0.59	0.59	0.35
ECS-28	221.5	221.7	0.14	0.14	0.02
ECS-30	220.2	220.6	0.38	0.38	0.14
ECS-31	223.0	222.8	-0.19	0.19	0.04
OBG-7	228.9	228.3	-0.55	0.55	0.30
OBG-8	228.4	227.6	-0.83	0.83	0.69
OBG-10	229.7	229.2	-0.51	0.51	0.26
OBG-11	226.5	225.9	-0.58	0.58	0.34
OBG-41	228.2	228.6	0.41	0.41	0.17
CEA-2	229.3	229.3	-0.03	0.03	0.00
CEA-4	228.7	228.2	-0.53	0.53	0.28
CEA-5	229.1	228.6	-0.49	0.49	0.24
ECS-22	229.0	228.6	-0.41	0.41	0.17
MP-1	223.4	223.3	-0.06	0.06	0.00
MP-2	229.3	229.4	0.11	0.11	0.01
MP-3	223.3	223.3	-0.02	0.02	0.00
MP-4	219.6	219.8	0.21	0.21	0.04
MP-10	217.5	219.5	2.00	2.00	4.00
MP-11S	224.3	223.9	-0.39	0.39	0.15
MP-14S	229.35	229.5	0.15	0.15	0.02
Total:	7182.6	7183.1	0.53	18.51	16.48
			ME[b/] =	0.02	
			MAE[c/] =	0.58	
			RMS[d/] =	0.72	4.6

[a/] Water levels are in feet mean-sea-level.

[b/] ME = Mean Error =1/n x (h_m-h_s).

[c/] MAE = Mean Average Error = 1/n x |(h_m-h_s)|.

[d/] RMS = Root-Mean-Square (RMS) Error = $(1/n \times (h_m-h_s)^2)^{0.5}$.

Measured Heads vs. Simulated Heads
Westover ARB, Massachusetts

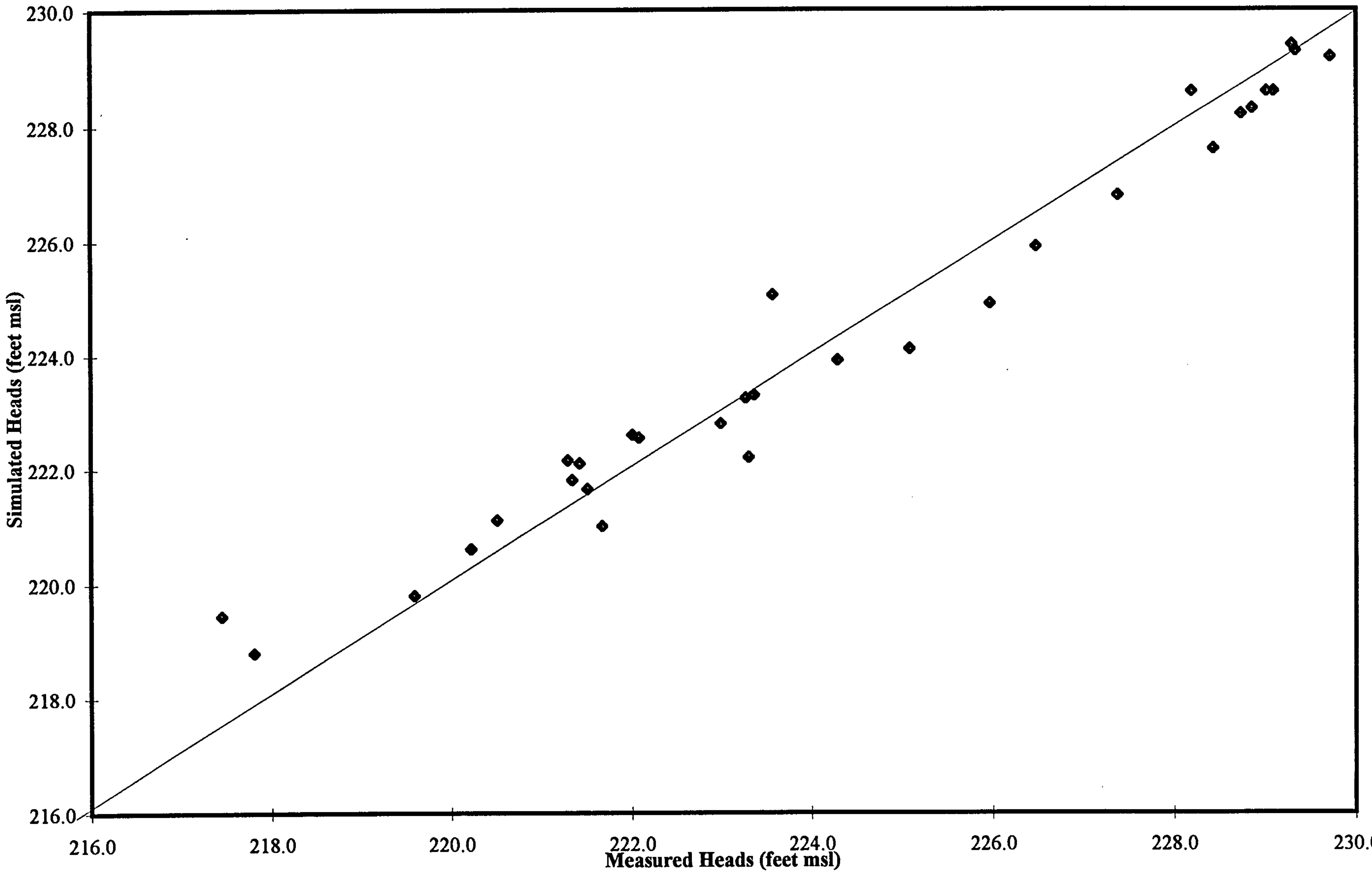

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TABLE
CALCULATION OF RETARDATION COEFFICIENTS
ASSUMING TOC CONTENT = ONE-HALF THE DETECTION LIMIT
ZONE 1
REMEDIATION BY NATURAL ATTENUATION TS
WESTOVER ARB, MASSACHUSETTS

Compound	K_{oc} (L/kg [a])	Average Fraction Organic Carbon [b]	Distribution Coefficient K_d (L/kg) Average [c]	Bulk Density (kg/L) [d]	Effective Porosity [a]	Coefficient of Retardation Average	Advective Groundwater Velocity (ft/day) [a]	Contaminant Velocity (ft/day)	Contaminant Velocity (ft/year)
Benzene	79	0.00025	0.020	1.65	0.25	1.13	0.2900	0.25656	94
Toluene	190	0.00025	0.048	1.65	0.25	1.31	0.2900	0.22078	81
Ethylbenzene	468	0.00025	0.117	1.65	0.25	1.77	0.2900	0.16364	60
m-xylene	405	0.00025	0.101	1.65	0.25	1.67	0.2900	0.17383	63
o-xylene	422	0.00025	0.106	1.65	0.25	1.70	0.2900	0.17096	62
p-xylene	357	0.00025	0.089	1.65	0.25	1.59	0.2900	0.18250	67

NOTES:
[a] From technical protocol document (Wiedemeier *et al.*, 1995) and Groundwater Chemical Desk Reference (Montgomery and Welkom, 1990).
[b] From site data.
[c] K_d = Average Fraction Organic Carbon x K_{oc}.
[d] Literature values.

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APPENDIX D

MODEL INPUT AND OUTPUT (ELECTRONIC)

An electronic copy of model results was not included in this copy of the Treatability Study. At least one electronic copy of the model results is available from one of the following sources:

◊ Parsons Engineering Science, Inc., Denver, Colorado

◊ Air Force Center for Environmental Excellence (AFCEE), Technology Transfer Division, Brooks Air Force Base, Texas

◊ Westover Air Reserve Base, 439th SPTG/CEV, Westover Air Reserve Base, Massachusetts

APPENDIX E

COST ESTIMATE CALCULATIONS

Present Worth Analysis

Annual Adjustment Factor = 7%

Alternative 1: Natural Attenuation with Institutional Controls and Long-Term Groundwater Monitoring	years	Present Worth ($)	Cost ($) at Year Indicated Year: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Maintain Institutional Controls	22	$55,306	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000
Long-term Monitoring																								
Install New Wells	1	$35,281	$37,751	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Groundwater Sampling (annual)	5	$84,554	$20,622	$20,622	$20,622	$20,622	$20,622	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Groundwater Sampling (semiannual)	17	$71,450	$0	$0	$0	$0	$0	$0	$20,622	$0	$20,622	$0	$20,622	$0	$20,622	$0	$20,622	$0	$20,622	$0	$20,622	$0	$20,622	$0
Reporting/Project Mgmt (annual)	5	$21,801	$5,317	$5,317	$5,317	$5,317	$5,317	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$5,317	$0
Reporting/Project Mgmt (semiannual)	17	$14,536	$0	$0	$0	$0	$0	$0	$5,317	$0	$5,317	$0	$5,317	$0	$5,317	$0	$5,317	$0	$5,317	$0	$5,317	$0	$5,317	$0
Subtotal Present Worth ($)		$282,929																						

Total Present Worth Cost ($): $282,929

Present Worth Analysis

Annual Adjustment Factor = 7%

Alternative 2: Natural Attenuation and Passive LNAPL Recovery with Institutional Controls and Long-Term Monitoring		Present Worth	Cost ($) at Year Indicated															
	years	($)	Year: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Passive LNAPL Recovery																		
System Installation	1	$2,277	$2,436	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
System Maintenance	2	$12,873	$7,120	$7,120	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Annual Report	2	$2,567	$1,420	$1,420	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Subtotal Present Worth ($)		$17,717																
Maintain Institutional Controls	16	$47,233	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000
Long-term Monitoring																		
Install New Wells	1	$35,281	$37,751	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Groundwater Sampling (annual)	5	$84,554	$20,622	$20,622	$20,622	$20,622	$20,622	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Groundwater Sampling (semiannual)	11	$49,888	$0	$0	$0	$0	$0	$0	$20,622	$0	$20,622	$0	$20,622	$0	$20,622	$0	$20,622	$0
Reporting/Project Mgmt (annual)	5	$21,801	$5,317	$5,317	$5,317	$5,317	$5,317	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Reporting/Project Mgmt (semiannual)	11	$13,497	$0	$0	$0	$0	$0	$0	$5,317	$0	$5,317	$0	$5,317	$0	$5,317	$0	$5,317	$0
Subtotal Present Worth ($)		$252,255																

Total Present Worth Cost ($): $269,972

Present Worth Analysis

Annual Adjustment Factor = 7%

Alternative 3: Natural Attenuation, Passive LNAPL Removal, Pump and Treat with Institutional Controls and Long-Term Monitoring		Present Worth	Cost ($) at Year Indicated				
	years	($)	Year: 1	2	3	4	5
Passive LNAPL Recovery							
System Installation	1	$2,277	$2,436	$0	$0	$0	$0
System Maintenance	2	$12,873	$7,120	$7,120	$0	$0	$0
Annual Report	2	$2,567	$1,420	$1,420	$0	$0	$0
Subtotal Present Worth ($)		$17,717					
Maintain Institutional Controls	5	$20,501	$5,000	$5,000	$5,000	$5,000	$5,000
Long-term Monitoring							
Install New Wells	1	$35,281	$37,751	$0	$0	$0	$0
Groundwater Sampling	5	$84,554	$20,622	$20,622	$20,622	$20,622	$20,622
Reporting/Project Mgmt	5	$21,801	$5,317	$5,317	$5,317	$5,317	$5,317
Subtotal Present Worth ($)		$162,137					
Groundwater Extraction							
Design and Installation	1	$105,592	$112,983	$0	$0	$0	$0
System Maintenance	2	$56,285	$31,131	$31,131	$0	$0	$0
Reporting Costs	2	$10,262	$5,676	$5,676	$0	$0	$0
		$172,139					

Total Present Worth Cost ($): $351,994

Alternatives 1, 2, and 3: Long-Term Monitoring and Institutional Controls
Standard Rate Schedule

Billing Category Cost Code/(Billing Category)		Billing Rate	Task 1 (hrs)	Install New LTM/POC Wells ($)	Task 2 (hrs)	Sampling ($)	Task 3 (hrs)	Reporting & PM ($)
Word Processor	88/(15)	$30	0	$0	0	$0	8	$240
CADD Operator	58/(25)	$47	4	$188	0	$0	16	$752
Technician	42/(50)	$40	10	$400	40	$1,600	10	$400
Staff Level	16/(65)	$57	80	$4,560	40	$2,280	30	$1,710
Project Level	12/(70)	$65	4	$260	4	$260	10	$650
Senior Level	10/(80)	$85	1	$85	0	$0	3	$255
Principal	02/(85)	$97	0	$0	0	$0	0	$0
Total Labor (hrs | $)			99	$5,493	84	$4,140	77	$4,007
ODCs								
Phone				$30		$0		$50
Photocopy				$20		$0		$150
Mail				$100		$400		$60
Computer				$150		$0		$400
CAD				$0		$0		$450
WP				$0		$0		$200
Travel				$1,000		$2,000		$0
Per Diem				$1,358		$780		$0
Eqpt. & Supplies				$400		$200		$0
Total ODCs				$3,058		$3,380		$1,310
Outside Services								
LTM/POC Well Installation Costs [a/]				$29,200		$0		$0
Laboratory Fees [b/]				$0	27 LTM, 3 qa/qc	$13,102		$0
Other: Maintain Institutional Controls				$0		$0		$5,000
Total Outside Services				$29,200		$13,102		$5,000

Proposal Estimate	Task 1	Task 2	Task 3
Labor	$5,493	$4,140	$4,007
ODC's	$3,058	$3,380	$1,310
Outside Services	$29,200	$13,102	$5,000
Total by Task	$37,751	$20,622	$10,317

Total Labor	$13,640
Total ODCs	$7,748
Total Outside Services	$47,302
Total Project	$68,690

Task 1: Install New LTM/POC Wells
Task 2: Sampling per Event
Task 3: Reporting and PM per Sampling Event

Alternatives 2 and 3: Passive LNAPL Removal

Standard Rate Schedule

Billing Category Cost Code/(Billing Category)	Billing Rate	Task 1 (hrs)	Design & Install Recovey System ($)	Task 2 (hrs)	System Monitoring/ Maintenance (2x per mo)($)	Task 3 (hrs)	Annual Report ($)
Word Processor 88/(15)	$30	0	$0	0	$0	4	$120
CADD Operator 58/(25)	$47	0	$0	0	$0	0	$0
Technician 42/(50)	$40	10	$400	0	$0	8	$320
Staff Level 16/(65)	$57	8	$456	0	$0	10	$570
Project Level 12/(70)	$65	4	$260	0	$0	2	$130
Senior Level 10/(80)	$85	0	$0	0	$0	0	$0
Principal 02/(85)	$97	0	$0	0	$0	0	$0
Total Labor (hrs|$)		22	$1,116	0	$0	24	$1,140
ODCs							
Phone			$20		$120		$20
Photocopy			$20		$60		$100
Mail			$100		$240		$40
Computer			$80		$0		$80
CAD			$0		$0		$0
WP			$100		$0		$40
Travel			$0		$0		$0
Per Diem			$0		$0		$0
Eqpt. & Supplies			$0		$200		$0
Total ODCs			$320		$620		$280
Outside Services							
Well Installation			$0		$0		$0
Recovery System Installation			$200		$0		$0
Equipment Costs			$800		$0		$0
Product Hauling/Disposal (Fuel)			$0		$500		$0
Other (O&M$120/day)			$0		$6,000		$0
Total Outside Services			$1,000		$6,500		$0

Estimate	Task 1	Task 2	Task 3
Labor	$1,116	$0	$1,140
ODC's	$320	$620	$280
Outside Services	$1,000	$6,500	$0
Total by Task	$2,436	$7,120	$1,420

Total Labor	$2,256
Total ODCs	$1,220
Total Outside Services	$7,500
Total Project	$10,976

Task 1: LNAPL Recovery System Design and Construction
Task 2: Monthly Site Time and Travel Costs (per year)
Task 3: Report Preparation

Alternative 3: Groundwater Extraction

Standard Rate Schedule

Billing Category Cost Code/(Billing Category)		Billing Rate	Task 1 (hrs)	Design & Install Recovery System ($)	Task 2 (hrs)	System Monitoring/ Maintenance (weekly)($)	Task 3 (hrs)	Completion Report ($)
Word Processor	88/(15)	$30	40	$1,200	0	$0	8	$240
CADD Operator	58/(25)	$47	120	$5,640	0	$0	8	$376
Technician	42/(50)	$40	200	$8,000	400	$16,000	16	$640
Staff Level	16/(65)	$57	200	$11,400	100	$5,700	40	$2,280
Project Level	12/(70)	$65	100	$6,500	40	$2,600	24	$1,560
Senior Level	10/(80)	$85	20	$1,700	0	$0	4	$340
Principal	02/(85)	$97	2	$194	0	$0	0	$0
Total Labor (hrs|$)			682	$34,634	540	$24,300	100	$5,436
ODCs								
Phone				$200		$60		$10
Photocopy				$100		$0		$50
Mail				$100		$120		$40
Computer				$200		$0		$40
CAD				$240		$0		$60
WP				$100		$0		$40
Travel				$0		$3,522		$0
Eqpt. & Supplies				$0		$500		$0
Total ODCs				$940		$4,202		$240
Outside Services								
Well Installation				$7,500		$0		$0
Recovery System Installation				$27,309		$0		$0
Equipment Costs				$42,000		$0		$0
Product Hauling/Disposal				$0		$0		$0
Electrical Costs				0		229		$0
Laboratory Fees				$600		$2,400		$0
Other				0		0		$0
Total Outside Services				$77,409		$2,629		$0

Estimate		Task 1	Task 2	Task 3
Labor		$34,634	$24,300	$5,436
ODC's		$940	$4,202	$240
Outside Services		$77,409	$2,629	$0
Total by Task		$112,983	$31,131	$5,676
Total Labor		$64,370		
Total ODCs		$5,382		
Total Outside Services		$80,038		
Total Project		$149,790		

Task 1: Passive LNAPL Recovery System Design and Construction
Task 2: Monthly Site Time and Travel Costs (per year)
Task 3: Report Preparation

tover ARB Backup Calculations

Alternatives 1, 2 and 3: Long-term Monitoring

Misc calculations

Number of LTM wells:		
Number of wells:	16	
Depth each:	30	ft

Cost calculations

Description	Unit	Qty.	Unit Price	Subtotal	Total	Source (If applicable)
Well Installation					$ 29,200	
Mobilization	ea	1	$ 2,000	$ 2,000		
Well Installation	ln ft	480	$ 50	$ 24,000		
Soil Disposal	drum	32	$ 100	$ 3,200		

Alternatives 2 and 3: Passive LNAPL Recovery

Misc calculations

Passive LNAPL Recovery System:		
Number of wells:	1	
Number of years:	2	

Cost calculations

Description	Unit	Qty.	Unit Price	Subtotal	Total	Source (If applicable)
					$ 20,000	
Skimmer	ea	1	$ 800	$ 800		
Installation	hours	8	$ 60	$ 480		
O&M	week	104	$ 180	$ 18,720		

Alternative 3: Groundwater Extraction System

Misc calculations

Number of groundwater extraction wells:		
Number of wells:	2	
Depth each:	40	ft
Trench Volume/Area		
Width:	12	in
Depth:	2	ft
Length:	1,000	ft
Volume:	2,000	cf
	74	cy
Surface Area:	1,000	sf
	111	sy

Cost calculations

Description	Unit	Qty.	Unit Pric	Subtotal	Total	Source (If applicable)
Well Installation					$ 7,500	
Mobilization	ea	1	$ 2,000	$ 2,000		
Well Installation	ln ft	80	$ 60	$ 4,800		
Soil Disposal	drum	7	$ 100	$ 700		
Equipment Costs					$ 42,000	
Pumps	ea	2	$ 1,500	$ 3,000		
Air Stripper	ea	2	$ 18,000	$ 36,000		
Pump Electronics	ea	2	$ 1,500	$ 3,000		Means 132 151 5540
System Installation					$ 27,309	
Mob/Demob	ea	1	$1,000	$ 1,000		
Trenching	cy	74	$5.05	$ 374		Means 022 254 0050
Pipe laying	ln ft	1,200	$13.05	$ 15,660		Means 151 701 0550/026 686 2800
Backfill	cy	74	$17.20	$ 1,273		Means 022 204 0600
Compaction	cy	74	$5.10	$ 377		Means 022 204 0600
Pavement Base	sy	-	$5.25	-		Means 022 308 0100
Reseeding	sy	222	$ 2	$ 424		Means 029 304 0310
Piping	lf	100	$9.30	$ 930		Means 151 551 1880
Mechanical	man hr	20	$ 39	$ 777		Means Q-1 crew
Electrical	ls	1	$ 5,000	$ 5,000		
Slab	cy	2	$97.00	$ 194		Means 033 130 4700
Building	ea	-	$4,925	-		Means 131 221 0010
Contingency	%	5%	$26,009	$ 1,300		
				$ -		
Product Hauling /Disposal	load	-	$	-		Assumed to be free-of-charge

PARSONS

Calculation Sheet

Rev	By	Date	Ck	Date	Title Groundwater Extraction System Design
	MV	5/7/97			
					Author M. Vessely Sheet 1 Of 1

1) RADIUS of INFLUENCE: (R_o) For Unconfined Aquifers

$$R_o = 575\ \Delta S \sqrt{H \cdot K}$$

ΔS = drawdown in meters
H = initial saturated thickness in meters
K = Hydraulic Conductivity in m/s
575 = Conversion factor

Source: Maximov, V.M. (ed.) 1967, The Handbook For Hydrogeologists, Volume 1, Translated from russian for the US Dept of Interior, Bureau of Reclamation and the National Science foundation by the Indian scientific Documentation Centre, New Delhi, 1975.

2) Pumping RATE for radial flow in an Unconfined Aquifer

$$Q = \frac{K(H^2 - h_w^2)}{458 \ln\left(\frac{R_o}{r_w}\right)}$$

where: K = hydraulic conductivity in GPD/ft^2
H = initial saturated thickness in ft
h_w = saturated thickness @ well during pumping (ft)
R_o = radius of influence in ft.
r_w = well casing radius in ft.

Source: (Powers, 1981)
Note: Equation Assumes 100% well Efficiency

K from slug tests $\cong$ 5.7 m/day − 0.000066 m/s
H is the Estimated depth of Contamination $\cong$ 40 ft or $\cong$ 12.5 meters
ΔS (assume a drawdown of 2/3 saturated thickness) = 2/3(12.5) = 8.2 meters

$$R_o = 575\,(8.2)\sqrt{(12.5)(6.6\times10^{-5}\tfrac{m}{s})} = 135\ m\ \ \underline{(430\ ft)}\ \text{radius of influence}$$

h_w assuming a 67% well efficiency (Driscoll, 1986 p217)
$= H - H(0.67) = 12.5 - 8.25 = 4.25\ m\ \ (13.6\ ft)$

1949.70

$$\therefore\quad Q = \frac{K(H^2-h_w^2)}{458\ln\left(\frac{R_o}{r_w}\right)} = \frac{136\ \frac{gpd}{ft^2}\,(40ft^2 - 12.9ft^2)}{458\ \ln\left(\frac{430\ ft}{0.167 ft}\right)} = \underline{54\ gpm}$$

3596.